C·55
578

Illinois U Library

PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

Edited and Issued Monthly by

THE INSTITUTION OF ELECTRICAL ENGINEERS

In Association with

THE PHYSICAL SOCIETY

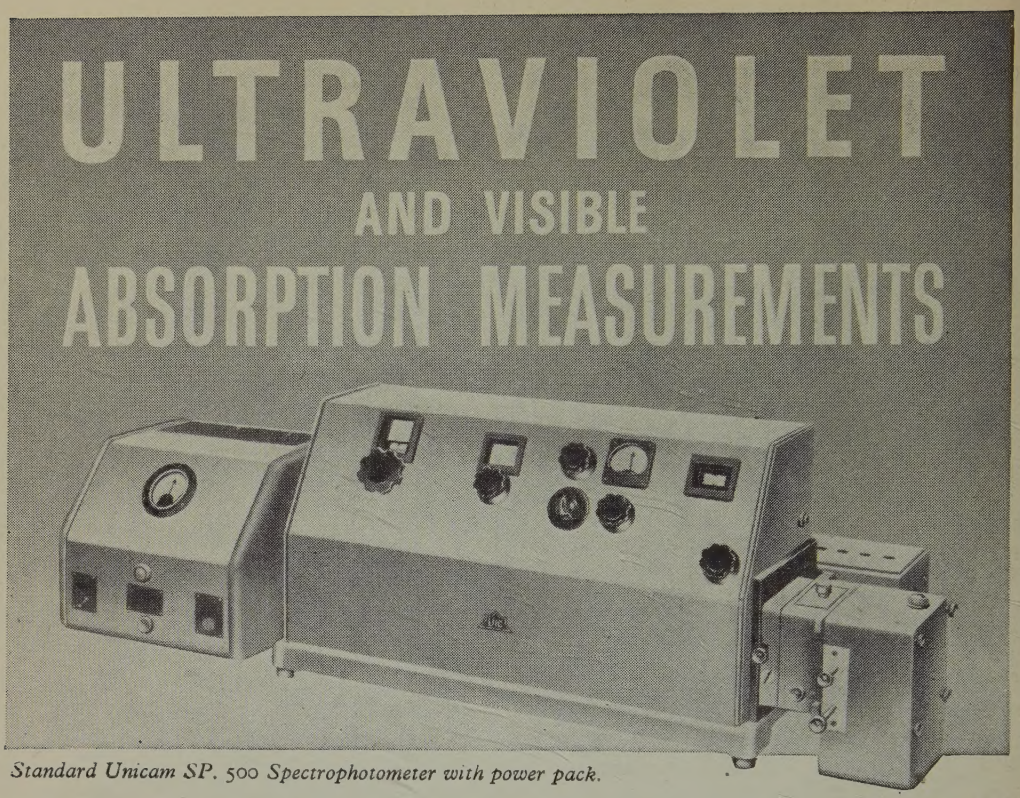
THE AMERICAN PHYSICAL SOCIETY

THE AMERICAN
INSTITUTE OF ELECTRICAL ENGINEERS

ABSTRACTS 1376–2339

VOLUME 55 **MARCH 1952** NUMBER 651

ULTRAVIOLET AND VISIBLE ABSORPTION MEASUREMENTS



Standard Unicam SP. 500 Spectrophotometer with power pack.

The Unicam SP.500 Quartz Spectrophotometer is designed for the rapid and accurate identification, qualitative and quantitative analysis of chemical solutions by measurement of light absorption or transmission at wavelengths from 2,000Å to 10,000Å. This instrument combines simplicity of operation with performance factors of a high order, including fine resolution, an excellent degree of reproducibility, and exceptionally stable dark current, which reduces the necessity for check readings.
The adaptability of the spectrophotometer is increased by the addition of accessories. These include a reflectance attachment for the measurement of opaque surfaces, a fluorimetry or nephelometry attachment and a 10cm cell housing to facilitate the examination of gases or vapours.

An illustrated leaflet describing the instrument in detail will gladly be sent on request.

UNICAM

UNICAM INSTRUMENTS (CAMBRIDGE) LTD., ARBURY WORKS, CAMBRIDGE, ENGLAND

Principal Contents

MARCH 1952

		PAGE
51	MATHEMATICS	153
52	ASTRONOMY. ASTRO-PHYSICS. GEODESY	154
53	PHYSICS	158
530.1	Fundamentals	159
531	General mechanics. Mechanics of solids	166
531.7	Mechanical measurements	166
532	Mechanics of fluids	167
532.6	Capillarity	169
532.7	Molecular theory of liquids	169
533	Mechanics of gases	170
533.7	Molecular theory of gases	173
534	Vibrations. Acoustics	173
535	Optics. Radiation. Spectra	181
536	Heat	193
536.7/.8	Thermodynamics	198
537	Electricity	199
537.1	Theory. Electrons	199
537.2	Electrostatics. Dielectrics	199
537.3	Electric conduction. Currents	202
537.52	Electric discharges	208
537.531	X-rays	210
537.533/.534	Cathode rays. Positive rays	211
537.54	Discharge tubes. Counters	217
537.56/.58	Ionization. Thermionics	220
537.591	Cosmic rays	221
538	Magnetism	224
538.3/.5	Electromagnetism. Electrodynamics	228
538.56	Electromagnetic waves and oscillators	229
538.6	Magnetic effects	231
539.1	Molecular and atomic structure	232
539.11	Theory of solid state	232
539.13	Molecular structure	232
539.15	Atomic structure. Nucleus. Isotopes	236
539.16	Radioactivity. α-, β- and γ-rays	238
539.17	Nuclear reactions	242
539.18	Atom and molecule beams. Mesons. Neutrons	247
539.2	Structure of solids	249
539.3/.8	Elasticity. Strength. Rheology	251
541	PHYSICAL CHEMISTRY	255
541.11/.12	Phase equilibrium. Chemical reactions	255
541.13	Electrochemistry	256
541.14/.15	Photochemistry. Radiation chemistry	257
541.18	Dispersions. Colloids. Adsorption	257
541.2/.6	Chemical structure	258
542.1/.7	Laboratory apparatus	259
542.9	Chemical processes	—
543/545	Chemical analysis	259
548	CRYSTALLOGRAPHY	260
548.7	Molecular and X-ray crystallography	261
55	GEOPHYSICS	265
551.5	Atmosphere. Meteorology	267
57/59	BIOLOGY	272
61	Medical science. Human physiology	272
66/67	TECHNICAL MATERIALS	—
77	PHOTOGRAPHY	276

RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Mechanical testing
Non-destructive testing
Industrial radiography
Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Amplifiers
Radiocommunication
Mechanical engineering
Illumination
Metallurgy

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 53 (1950) and the Supplements published with the Indexes to Volume 53 (1950) and Volume 54 (1951). Reprints of the List of Journals (1950) and the Supplements (1950, 1951) can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Journals marked * are not received regularly.

Appl. Spectroscopy	*Applied Spectroscopy.* Calco Chemical Division, American Cyanamid Co., Bound Brook, New Jersey.
Bull. Elect. Engng Educ.	*Bulletin of Electrical Engineering Education.* College of Technology, Manchester 1.
**Elect. Ind.*	*Electrical Industries.* 23 Great Queen Street, London, W.C.2.
**Kunststoffe*	*Kunststoffe.* [Abstracted by *Index Aeronauticus.*]
**Mem. Fac. Techn. Tokyo Metrop. Univ.*	*Memoirs of the Faculty of Technology. Tokyo Metropolitan University.* Tokyo.
Mem. Res. Inst. Acoust. Sci. Osaka	*Memoirs of the Research Institute of Acoustical Science. Osaka National University.* Nagisi, Hirakate-shi, Osaka-fu.
Photoelect. Spectrom. Group Bull.	*Photoelectric Spectrometry Group Bulletin.* Unicam Instruments (Cambridge), Arbury Works, Cambridge.
Proc. Instn Civ. Engrs	*Proceedings of the Institution of Civil Engineers.* Formerly *Journal of the Institution of Civil Engineers* [*J. Instn Civ. Engrs*].
Prof. Notes Meteorol. Off. [*Lond.*]	*Professional Notes. Meteorological Office* [*Air Ministry.*] H.M. Stationery Office, Kingsway, London, W.C.2.
**Rech. Aéronaut.*	*La Recherche Aéronautique.* [Abstracted by *Applied Mechanics Reviews.*]
Roy. Soc. N.S.W. Monogr.	*Royal Society of New South Wales. Monograph.* Science House, 157 Gloucester Street, Sydney.
**Simon Stevin*	*Simon Stevin.* Erven P. Noordhoff, Oude Boteringestraat 12, Groningen.
**Tech. Mem. Nat. Adv. Comm. Aeronaut.*	*Technical Memoirs of the National Advisory Committee on Aeronautics.* [Abstracted by *Applied Mechanics Reviews.*]
U.R.S.I. Inform. Bull.	*U.R.S.I. Information Bulletin.* U.R.S.I. [International Scientific Radio Union]. 42 rue des Minimes, Brussels.
Univ. Microfilms	*University Microfilms,* 313 North First Street, Ann Arbor, Michigan.
**Verh. Schweiz. Naturforsch. Ges.*	*Verhandlungen der Schweizer Naturforschenden Gesellschaft, Davos* (1950).

Abstracting Journals

RUBBER ABSTRACTS	Research Association of British Rubber Manufacturers. 105–7 Lansdowne Road, Croydon, Surrey.

Change of Title

J. Instn Civ. Engrs	*Journal of the Institution of Civil Engineers.* Title changed to *Proceedings of the Institution of Civil Engineers* [*Proc. Instn Civ. Engrs*] from 1952.

MATHEMATICS 51

517.6

1376. On a certain type of integral associated with circular cylinders. J. M. HAMMERSLEY. *Proc. Roy. Soc. A*, **210**, 98–110 (*Dec.* 7, 1951).

In this paper is discussed the numerical evaluation of the integral whose integrand is any given function of the distance between a pair of points in a right circular cylinder, the integration being over all such pairs of points. It is shown how to express such a sixfold integral as a single integral by means of an analytical reduction, which is independent of the functional form of the integrand; and a function is tabulated which occurs in the resulting single integration. These tables extend the existing tabulation of the hypergeometric function, and so may prove useful in other applications—for instance, in dynamical astronomy. The theory is illustrated with an example upon the absorption of radioactive radiation in rods.

517.75

1377. Hamiltonians without parametrization. R. H. PENFIELD. *Phys. Rev.*, **84**, 737–43 (*Nov.* 15, 1951).

Theories which are covariant with respect to transformation groups involving arbitrary functions cannot be of the Cauchy–Kowalewski type. Therefore, it would appear that such theories cannot be cast into a Hamiltonian formalism. However, a Hamiltonian function can be formed although it is, to a certain extent arbitrary. This lack of uniqueness is an immediate consequence of the covariance requirements. The adoption of a particular Hamiltonian function destroys the covariance of the theory. This situation is similar to the introduction of "cordinate conditions" in the theory of gravitation or the use of the Lorentz gauge condition in electrodynamics. A.

517.9 : 530.145.7

1378. Some theorems on perturbation theory. IV. E. C. TITCHMARSH. *Proc. Roy. Soc. A*, **210**, 30–47 (*Dec.* 7, 1951).

For Pt III, see Abstr. 6195 (1951). A general analysis is given of the perturbation problem in which the perturbed equation has a continuous spectrum, while the unperturbed equation has a discrete spectrum. It is shown that in a certain class of cases the function which determines the spectrum has, in the perturbed case, a pole just below the real axis, so that instead of a perturbed eigenvalue there is a point in the neighbourhood of which the perturbed spectrum is highly concentrated. A.

518.2

1379. Table of the integral $\int_0^x e^{-u^3}\,du$. M. ABRAMOWITZ. *J. Math. Phys.*, **30**, 162–3 (*Oct.*, 1951).

518.3 : 538.566.3 : 621.391.09 : 621.3.012.3

1380. A general method for construction of nomograms. A. RAMBØL. *Tekn. Ukebl.*, **98**, 855–60 (*Nov.* 15, 1951) *In Norwegian.*

If the function $F(u, v, w) = 0$ is to be represented in a nomogram, the scale equations are written in parameter form, $y = f_1(x)$, $x = x_1(u)$, $y = y_1(u)$; $y = f_2(x)$, $x = x_2(v)$, $y = y_2(v)$; $y = f_3(x)$, $x = x_3(w)$, $y = y_3(w)$, and the condition that the values of u, v, w satisfying the straight-line equation $ax + by + 1 = 0$ also satisfy $F = 0$ is expressed in determinant form. If, therefore, $F = 0$ is written in determinant form, reduced, by the aid of known theorems from the theory of determinants, to the form of the parameter determinant, the x- and y-functions are known and the scale lines can be drawn. Two examples are worked out in detail: deflection of radio waves from the ionosphere, and standing-wave ratio for cables at the sending and receiving ends. Methods for adjustment of scale equations to give convenient proportions of the nomogram are illustrated.

J. A. WILCKEN

518.5

1381. Photoelectric curve follower. H.-J. DREYER. *Z. angew. Phys.*, **3**, 453–6 (*No.* 12, 1951) *In German.*

A mathematical instrument for integration (differential analyser) is described. Its operation is independent of extraneous light sources which cause no error. Accuracy better than 0·1% of the max. ordinate is achieved. The ordinates of the measured curve can be transmitted to other instruments by means of special amplifiers. The mechanism can be used in mathematical instruments or in the control of machine tools (flame or electric cutting machines, etc.). W. SUMMER

518.5

1382. Automatic calculating machines. I. Historical development. II. Modern electronic machines. III. The use of an electronic machine. M. V. WILKES. *J. Roy. Soc. Arts*, **100**, 56–90 (*Dec.* 14, 1951).

Royal Society of Arts Cantor lectures. 21 refs.

518.5 : 621.317.729 : 621.318.572

1383. Solution of polynomial equations with the aid of the electrolytic tank. L. TASNY-TSCHIASSNY AND A. G. DOE. Letter in *Nature* [*Lond.*] **168**, 702–3 (*Oct.* 20, 1951).

The extension of Lucas's method [*C.R. Acad. Sci.* [*Paris*] **106**, 645, 1072 (1888)] to complex coefficients has been demonstrated by Bloch [*Int. Congr. Appl. Mech.*, **4**, 324 (*Paper* 28, 1948)]. A practical system for establishing adjustable complex electrode currents is described which employs a transformer with a floating and tapped secondary, sets of parallel admittances being connected to a limited number of tappings enabling any current to be adjusted to an accuracy of 0·1%. Any point of the electrolyte can be earthed, an ordinary amplifier and vibration galvanometer suffices, and a quadruple probe assembly used for obtaining gradients in two perpendicular directions, which, with a suitable passive network can give zero output for circular polarization of the field. The use of an additional electrode as the variable enables the quick computation of the values of a rational function with given poles for any complex argument. A. J. KENNEDY

518.5 : 621.317.79

1384. A circuit for generating polynomials and finding their zeros. F. W. Bubb, Jr. *Proc. Inst. Radio Engrs*, **39**, 1556–61 (*Dec.*, 1951).

This paper describes an instrument for generating any polynomial and for finding the roots of any polynomial equation to any desired degree of accuracy. A.

519.2

1385. A statistical distribution function of wide applicability. W. Weibull. *J. Appl. Mech.*, **18**, 293–7 (*Sept.*, 1951).

Discusses the applicability of statistics to a wide field of problems. Examples of simple and complex distributions are given. A.

519.271

1386. The fitting of polynomials to unequally-spaced data. J. G. Hayes and T. Vickers. *Phil. Mag.*, **42**, 1387–1400 (*Dec.*, 1951).

ASTRONOMY . ASTROPHYSICS . GEODESY 52

522.617 : 535.89

1387. The fundamental standard of wavelength. W. F. Meggers. *Astron. J.*, **56**, 116–18 (*Oct.*, 1951).

Lists are given of measures of the red Cd line and, relative to this, of the more accurate and practical artificial Hg^{198} isotope line whose mean λ is found to be $5460{\cdot}75318 \pm 0{\cdot}00006$. Applications of the robust Hg^{198} lamp are mentioned, and it is suggested that this standard should be used in future astrophysical work. D. L. EDWARDS

522.617.1

1388. A double telescope for visual photometry. W. Strohmeier. *Astron. Nachr*, **279**, 183–5 (*April*, 1951) *In German.*

Comparison of the stellar images in the two telescopes is made by means of iris diaphragms mounted before the objectives. An accuracy of 0^m1 for a single reading can be obtained in 3 colours. M. W. OVENDEN

523.11

1389. Explorations in space. The cosmological program for the Palomar telescopes. E. P. Hubble. *Proc. Amer. Phil. Soc.*, **95**, 461–70 (*No.* 5, 1951).

A popular survey of investigations to be undertaken. R. A. NEWING

523.11

1390. The evolution of galaxies and stars. C. F. von Weizsäcker. *Astrophys. J.*, **114**, 165–86 (*Sept.*, 1951).

A hydrodynamical scheme of evolution is proposed, confined to events after the time when the average density in the universe was comparable to the density inside a galaxy at our time. Gas in cosmic space is moving according to hydrodynamics, mostly in a turbulent and compressible manner. Dust is carried with the gas, probably by magnetic coupling. Star systems cannot be described hydrodynamically, and hence do not show turbulence and supersonic compressibility. According to the spectral law of incompressible turbulence, the relative velocity of two points at a distance l is proportional to $l^{1/3}$. This is deduced from the picture of a hierarchy of eddies. Compressibility and interstellar clouds are discussed and a hierarchy of clouds is considered. General evolutional scheme for a gaseous body: a gravitationally stable, turbulent cloud is first flattened into a rotating disk, which then is dissolved into a uniformly rotating central body and a part returning into cosmic space. The time scale of these changes is somewhat larger than the diameter of the cloud divided by the turbulent velocity. The origin of galaxies seems to have been by a competition between expansion and turbulence. The evolution of galaxies and spiral structure: irregular nebulae must be young, spirals intermediate, elliptical nebulae genetically old. Spiral structure is the distortion of turbulent clouds by non-uniform rotation. A bar is more stable than a disk. A two-armed spiral seems to be a distorted bar. In discussing the origin of the stars three groups of stars are considered instead of Baade's two populations: (*a*) stars belonging to the galactic centre dynamically; (*b*) old stars belonging to the disk; (*c*) "young" stars. Stars could be formed as long as there were no stars present, because stellar radiation inhibits the contraction of clouds to form new stars. "Young stars" seem to be, more exactly, rejuvenated stars. The mechanism of the accretion of interstellar matter by a star is discussed hydrodynamically. Stars must be formed rotating because of the turbulence of the original clouds. They lose their rotation probably by a combined magnetic-hydrodynamic process. Both formation and loss of rotation provide gaseous disks in which planets and double stars can be formed. Modifications of the author's theory on the origin of planets are discussed. Giants seem to have highly condensed cores. Their model may be non-stationary, with a slowly expanding atmosphere. Planetary nebulae then would be special types of giants. A.

523.11

1391. The birth of stars from interstellar clouds. L. Spitzer, Jr. *J. Wash. Acad. Sci.*, **41**, 309–18 (*Oct.*, 1951).

A popular review of the evidence for assigning different origins to stars of Baade's population types I (young cloud stars) and II (primeval stars). R. A. NEWING

523.11

1392. The gravitational instability of an infinite homogeneous turbulent medium. S. Chandrasekhar. *Proc. Roy. Soc. A*, **210**, 26–9 (*Dec.* 7, 1951).

Jeans's analysis of the problem of the gravitational stability of an infinite homogeneous medium is examined and the need for including turbulence in the discussion is pointed out. The subject is then reconsidered from the point of view of the modern theories of turbulence, and it is shown how eddies in

the density fluctuations which have wave numbers $k < \sqrt{[4\pi G\bar{\rho}/(c^2 + \frac{1}{3}\overline{u^2})]}$ (where c denotes the velocity of sound and $\overline{u^2}$ the mean square velocity of turbulence) are unstable in the sense that these fluctuations will grow with time. A.

523.16 : 535.5

1393. Some polarization measurements in astronomy. J. S. HALL. *J. Opt. Soc. Amer.*, **41**, 963–6 (*Dec.*, 1951).

Polarization of light in the galaxy as determined from the observations of 551 distant stars is discussed from the viewpoints of: (1) its nature and probable origin; (2) its space distribution, and (3) its relationship to such parameters as space reddening, the intensity of interstellar spectral lines, and the distance of the stars. Observations of polarized light from different portions of the Orion nebula are presented and its probable origin is briefly discussed. A.

523.161

1394. A method of observing turbulence of interstellar matter. S. VON HOERNER. *Z. Astrophys.*, **30**, 17–64 (*No.* 1, 1951) *In German.*

A general statistical method is developed for examining the mechanism of turbulence in an interstellar gas, in terms of obsd. spectroscopic measures of radial velocity. The results are applied to the special case of Orion nebula. The density of absorbing particles in this neb. is found to be $c\ 10^{-22}$ g/cm^3, in line with previous results. From a comparison with results derived from obsd. line-widths, it is concluded that turbulent anisotropic conditions exist, at least over small localized regions of the nebula.

D. R. BARBER

523.162.1

1395. A theory of interstellar polarization. L. SPITZER, JR AND J. W. TUKEY. *Astrophys. J.*, **114**, 187–205 (*Sept.*, 1951).

A detailed analysis is given of the polarization of starlight produced by ferromagnetic grains, oriented by an interstellar magnetic field. Lack of information on the optical properties of large elongated grains with a high refractive index prevents a consideration of grains with a circumference very much bigger than 8 000 Å, the longest wavelength at which polarization measures have been made. Grains of about this size, with a mean radius of $1{\cdot}3\times10^{-5}$ cm and composed primarily of Fe, Mg and their compounds, are shown to arise from collisions between ordinary grains, containing predominantly H_2O, NH_3 and CH_4. It is estimated that one out of every four grains is compound, with a shell of ices surrounding a dense nucleus of this sort. It is quite possible that such nuclei will be ferromagnetic; if so, they will all be highly magnetized single domains. However, a magnetic field of about 2×10^{-3} gauss is apparently required to orient these grains sufficiently to explain the observed polarization. Larger grains, which could be oriented by weaker fields, might form in two ways. First, the individual nuclei might stick together, forming long rods; this process will take place at an appreciable rate only if most of the grains occur in concentrations in which the density is one or two orders of magnitude greater than the assumed average cloud density. Second, successive collisions between compound nuclei and other grains would be expected to produce some ferromagnetic grains with relatively large radii. Since the optical properties of such large grains are unknown, whether or not they could explain the observed polarization is uncertain. A.

523.162.1

1396. The polarization of starlight by aligned dust grains. L. DAVIS, JR AND J. L. GREENSTEIN. *Astrophys. J.*, **114**, 206–40 (*Sept.*, 1951).

It is assumed that the grains contain mostly compounds of H with about 12% Fe by weight, presumably also in compounds. The theory of Gans is used to compute the scattering and absorption by a spheroidal grain small compared to the wavelength, the component of the light with its electric vector parallel to the grain's long axis being preferentially weakened. The polarization and extinction of light are then computed for a cloud of small particles (mean radius 10^{-5}–3×10^{-5} cm) having any specified distribution of orientations. The mechanism proposed for orienting the rapidly spinning grains (angular velocities of the order of 10^5–10^6 rad/sec) is the small non-conservative torque due to paramagnetic relaxation in material containing a few per cent of Fe. An approximate statistical theory based on a relaxation time for the orientation of the grains gives the distribution of orientations to be expected when this tendency toward orientation is balanced by the tendency toward random alignment caused by the bombardment of the grains by the interstellar gas. The theory predicts that for uniform magnetic fields and interstellar matter of constant temperature and composition the polarization should be proportional to the colour excess. The direction of the observed polarization vectors indicates that over regions of several hundred parsecs in the Milky Way the magnetic field is mainly parallel to the plane of the galaxy, perhaps nearly uniform along a spiral arm or perhaps making random whirls mainly in the plane of the galaxy. Since the interstellar grains are larger than those to which the Gans theory applies and since the predicted wavelength dependence of the extinction is incorrect, it is not surprising that the theory gives an incorrect wavelength dependence of the polarization. Qualitative considerations indicate that the predicted ratio p/E_1 is not too far from the correct order of magnitude and that present observations of the wavelength dependence do not necessarily contradict the rest of the theory, which can be extended when extinction coefficients are known for large grains. A.

523.162.1 : 523.872

Polarization of stellar radiation. *See Abstr.* 1412

523.4

1397. The stability of certain planetary models. I–II. E. SCHATZMAN. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 599–609 (*No.* 7, 1951) *In French.*

A mathematical treatment of two models (part I): (i) exhibiting two density discontinuities at pressures, P_1, P_2; and (ii) exhibiting one discontinuity at P_2 with core material density ρ_2, surrounded with concentric layer, density ρ_0, of material different from that of main body. Part II deals with the case of a more complex model with three density discontinuities.

D. R. BARBER

523.45

1398. A satellite model [composed] of ice. A. HUAUX. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 534–9 (*No.* 6, 1951) *In French.*

From a study of 10 different models, based on the properties of ice at high pressures, it is concluded that satellite IV of Jupiter may well be composed of ice, as suggested by H. Jeffreys. D. R. BARBER

523.53

1399. The wave-frequency dependence of the duration of radar-type echoes from meteor trails. V. C. PINEO AND T. N. GAUTIER. *Science*, **114**, 460–2 (*Nov.* 2, 1951).

Observations on 27·2 and 41·0 Mc/s confirm Lovell's conclusion that the duration is proportional to the square of the wavelength. Doubt is cast upon the interpretation of long-duration echoes as due to inhibition of diffusion by the terrestrial magnetic field. M. W. OVENDEN

523.53 : 538.566.2

1400. Theory of radio reflections from meteor trails. I. T. R. KAISER AND R. L. CLOSS. *Phil. Mag.*, **43**, 1–32 (*Jan.*, 1952).

Deals with the evaluation of the reflection coefficient for backward scattering of an electromagnetic wave from a column of ionization having cylindrical symmetry. The application of the theory to meteors thus depends on the assumption that a meteor instantaneously forms a narrow column of ionization which subsequently diffuses radially. The theory predicts two qualitatively different categories of meteor echoes, depending on whether the electron line density, α, is greater or less than about 10^{12} per cm, the properties of which may be summarized as follows: (1) $\alpha < 10^{12}$: If the incident electric vector is parallel to the axis of the trail (parallel scattering) it is sufficient to assume that the electrons scatter coherently and independently, each contributing an amount $4\pi(e^2/mc^2)^2$ to the backward scattering cross-section. As the column expands radially, the echo amplitude decreases, the form of decay being exponential if the electron density is a Gaussian function of radius. When the incident electric vector is normal to the column (transverse scattering) the echo amplitude differs from the above in that the reflection coefficient may pass through a resonance, followed by the exponential decay. The magnitude of the resonant reflection coefficient to that for parallel scattering) depends mainly on the diffuseness of the column (i.e. on the gradient of electron density at the radius of critical density). The echo amplitude in both cases is proportional to α, while the echo duration is independent of α. The short duration echoes which form the bulk of the experimental observations appear to have the above forms. (2) $\alpha \gg 10^{12}$: In this case the column is expected to reflect similarly to a metallic cylinder. Except initially, when the parallel reflection coefficient exceeds the transverse, the reflection coefficients are equal and substantially constant. The duration is approximately proportional to α, and the peak echo amplitude is a slowly increasing function of α ($\sim \alpha^{1/4}$). These predictions are in agreement with the experimental data on long duration echoes. A.

523.72

1401. The temperature structure of the sun's atmosphere in radiative equilibrium, taking into account the Fraunhofer lines. D. LABS. *Z. Astrophys.*, **29**, 199–252 (*No.* 3, 1951) *In German.*

Suitable theoretical models are devised to show: (1) Fraunhofer lines can only influence the temperatures of those layers in which they originate; (2) the sum of their effects is due to a close interaction between those caused by the strong and the faint lines, respectively; (3) coherent and incoherent scattering do not affect the temperature distribution appreciably; (4) details of a temperature inversion are deduced. In addition, the temperature structure is examined with the "grey temperature" model, and methods recently developed by Unsöld [Abstr. 2313 (1948)] and by Strömgren. The whole range of the solar spectrum is statistically divided into 13 regions; the dependence on wavelength of the line absorption coefficients is approximated by a step-function; the temperature distribution found hardly deviates from the "grey" one, except for the outermost layers ($\tau < 0{\cdot}01$); for the sun's actual surface temperature a value of about 4 300°K is indicated. A. BEER

523.72

1402. Circular polarization of 10·7-centimetre solar noise bursts. A. E. COVINGTON. *J. Roy. Astron. Soc. Can.*, **44**, 157–61 (*July–Aug.*, 1951).

During solar noise bursts on a wavelength of 10·7 cm, the intensities of the right-handed and left-handed circularly polarized radiations have been recorded. The more intense bursts can be grouped according to whether the intensities of the right-handed and the left-handed components are: (1) equal, or (2) unequal, or (3) whether only one component alone is present. When only one component is recorded, the radiation is circularly polarized. A.

523.746

1403. The impossibility of determining the sun's general magnetic field by Zeeman effect measurements. H. ALFVÉN. Letter in *Nature* [*Lond.*] **168**, 1036 (*Dec.* 15, 1951).

Application of the magneto-hydrodynamic theory of sunspots, which introduces turbulence, to the observed rate of progression of the sunspot zone leads to a theoretical value of the sun's general magnetic field of $39 > H > 9$ gauss. The recent observational conclusions by Thiessen, v. Klüber and Kiepenheuer, leading to a negligibly small general field, are by Alfvén considered to be legitimate only then if there is no turbulence in the sun's photosphere. A. BEER

523.75

1404. On the theory of the polarization of H_α and D_3 in prominences. G. THIESSEN. *Z. Astrophys.*, **30**, 8–16 (*No.* 1, 1951) *In German.*

The degree of polarization in prominences of small optical thickness is calculated for the lines H_α and D_3 (He I). Here the polarization effect was first discovered ($< 1{\cdot}5\%$) by Lyot in 1934 and 1947, while in 1950 Zanstra developed its theory [Abstr. 5032 (1951)]. Thiessen performs the numerical integration of his new formulae for the two heights of 35 000 and 70 000 km above the sun's surface. The resulting data are of the order of a few per cent (0–9),

and are tabulated for the various lines, heights and orientations of the magnetic field. The plane of polarization is, in general, not perpendicular to the sun's surface: for angles of about 0°–35° between this surface and the magnetic field, the polarization-plane is perpendicular to the latter; for larger angles, however, it is parallel to it. A. BEER

523.75

1405. Characteristics of solar flares. R. S. RICHARDSON. *Astrophys. J.*, **114**, 356–66 (*Sept.*, 1951).

Attention is called to certain characteristics of the changes in area of solar flares which, on a much reduced time scale, are suggestive of the light-curves of novae. Different types of flares are discussed on the basis of these characteristics. A.

523.75

1406. Some observations of dark filaments in prominences. Y. ÖHMAN. *Astrophys. J.*, **114**, 367–9 (*Sept.*, 1951).

A number of spectrum plates of the corona obtained with a wide slit and a great number of photographs of prominences have been examined. Indications have been found of the presence in many prominences of apparently dark filaments, when observations are made in the Hα line. Though it is generally difficult to distinguish between "dark" filaments and rifts, some rather convincing cases suggesting the presence of faintly luminous lanes of absorbing matter have been detected. The observations have been confirmed by spectroheliographic material. Photographs of prominences have also given evidence in favour of the opinion that a "dark" structure is often associated with prominences. A.

523.841.1

1407. Remarks on the nova phenomenon. IV. E. SCHATZMAN. *Ann. Astrophys.*, **14**, 294–304 (*No.* 3, 1951) *In French.*

For Pt III, see Abstr. 4054 (1951). From a study of various nuclear reactions it is concluded that He^3 could exist in small quantities in a pre-nova, and that the reaction $He^3 + He^3 \rightarrow He^4 + H^1 + H^1$ could produce a detonation wave suitable for the author's theory of nova eruptions discussed in Pt III.

R. A. NEWING

523.841.1

1408. Remarks on the nova phenomenon. V. E. SCHATZMAN. *Ann. Astrophys.*, **14**, 305–12 (*No.* 3, 1951) *In French.*

For Pt IV, see preceding abstract. He^3 is continuously formed from H by nuclear reactions, and considerations of vibrational stability suggest that an explosion would occur when the He^3 concentration becomes sufficiently large; the same process would lead to recurrent explosions. Approx. calculations suggest that the time between successive eruptions is $\propto E/L$, where E is energy liberated in an eruption and L the brightness between eruptions; this result is applied to SS Cygni stars and to novae.

R. A. NEWING

523.85

1409. Remark on the distribution of stars in the giant sequence. K. PILOWSKI. *Z. Astrophys.*, **29**, 257–61 (*No.* 3, 1951) *In German.*

523.852

1410. On the gravitational stability of an isothermal nebula. P. LEDOUX. *Ann. Astrophys.*, **14**, 438–47 (*No.* 4, 1951) *In French.*

Deals with the gravitational stability of an isothermal nebula stratified in plane parallel layers symmetrical with respect to a central plane of density ρ_0. It is shown that Jeans's criterion is still valid provided that one takes for the density which appears in it, the value $\rho_2/2$. This justifies the use made by G. P. Kuiper of Jeans's criterion in his discussions of the origin of the solar system. More generally, a preliminary condensation of nebulous matter according to this model might help in the formation by gravitational instability of smaller condensations than hitherto possible. A.

523.87 : 538.615

1411. The Zeeman effect in astrophysical spectra. III. Bright-line stellar spectra. C. E. R. BRUCE. *Rep. Brit. Elect. Res. Ass., Ref. L/T*248, 31 *pp.* (1951).

For Pt II, see Abstr. 2153 (1950). Consideration of the spectra of bright-line stars seems to confirm that phenomena connected with such spectra result from Zeeman rather than from Doppler effect. Since the report was first written, criticisms of some of the observational material employed and of other aspects of this work have been received. Their examination will require some time, and meanwhile it seems desirable to put the ideas on record. A.

523.872 : 523.162.1

1412. Polarization of stellar radiation. III. The polarization of 841 stars. W. A. HILTNER. *Astrophys. J.*, **114**, 241–71 (*Sept.*, 1951).

For Pt II, see Abstr. 5222 (1949). The polarization of 841 stars is given. The probable error of a single observation is 0·0022 mag. A.

523.877

1413. The condition for turbulence in rotating stars. T. G. COWLING. *Astrophys. J.*, **114**, 272–86 (*Sept.*, 1951).

The problem considered is whether stellar rotation has a stabilizing effect capable of preventing convection perpendicular to the axis of rotation. Stability for small displacements is studied. For axially symmetric displacements a stabilizing effect is found, in agreement with the earlier results of Randers and Walén. For non-symmetric displacements the stabilizing effect is less, and it disappears altogether for particular displacements. For the latter there is instability whenever the temperature gradient exceeds the adiabatic value. With non-uniform angular velocity, the shear may produce instability for slightly smaller temperature gradients. The displacements of maximum instability lead to a considerable convection of energy perpendicular to the axis of rotation, but this convection may possibly be less efficient than convection parallel to the axis. A.

523.877

1414. On the variation of turbulent velocities in stellar and solar atmospheres. S.-S. HUANG. *Astrophys. J.*, **114**, 287–96 (*Sept.*, 1951).

It is shown that Wright's observed relation between turbulent velocities and excitation potentials can be

understood if it is assumed that the mean turbulent velocity in stellar atmospheres decreases exponentially with optical depth in the atmosphere. Theoretical curves between turbulent velocities and excitation potentials derived on this assumption agree well with the observations. Wright's further result that the turbulent velocity is greater for ionized atoms than for the neutral atoms can also be interpreted, as also the variation of turbulent velocity required by Allen's analysis of the spectral lines at different points of the solar disk. A.

523.877

1415. Recent progress in stellar spectroscopy. O. STRUVE. *Astron. J.*, **56**, 114–15 (*Oct.*, 1951).

A note on the atmospheres of giant and supergiant stars, with special reference to the spectrum of ε Aur. and the "field of prominences" theory of such atmospheres. See Abstr. 8480 (1951). D. L. EDWARDS

523.877

1416. Stellar magnetism. H. W. BABCOCK. *Astron. J.*, **56**, 116 (*Oct.*, 1951).

Summarizes results obtained in 1946 on peculiar stars of types A–F with variable magnetic fields, some of which are periodic and show reversing fields.

D. L. EDWARDS

525.35

1417. Two causes contributing to the periodic fluctuation in the length of the day. A. YOUNG. *Bull. Acad. Roy. Belge Cl. Sci.*, **27**, 728–52 (*No.* 8–9, 1951).

Variations in the moment of inertia of the Earth are calculated from atmospheric pressure variations, and the resulting variations in the length of the day are obtained. The effect of polar waters released by differential seasonal melting is estimated. A.

525.37

1418. Variations in the period of the earth's rotation 1949–1950. F. PAVEL AND W. UHINK. *Astron. Nachr.*, **279**, 267–8 (*Aug.*, 1951) *In German.*

The results obtained with quartz clock Q3 at Potsdam are analysed and show that between April 1949 and April 1950 the amplitude of the yearly periodic term decreased and that of the half-yearly term increased. Equations of rate are calculated.

L. ESSEN

526.1

1419. Consideration of the contribution of Pizzetti and Somigliana to Stokes's problem. G. B. PACELLA. *Atti. Acad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **11**, 69–73 (*July–Aug.*, 1951) *In Italian.*

526.832

1420. *A priori* determination of the modulus of linear deformation for the transverse Mercator projection (Gauss conformal projection). A. MARUSSI. *Atti. Acad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **11**, 198–201 (*Sept.–Oct.*, 1951) *In Italian.*

Obtains a series expansion for the natural logarithm of the modulus from the differential equation satisfied by the logarithm. A. H. COOK

527

1421. The determination of position and velocity on the earth's surface. C. FOX. *J. Math. Phys.*, **30**, 146–55 (*Oct.*, 1951).

Sequel to a previous paper [Abstr. 6731 (1949)]. Shows how it is theoretically possible to determine latitude, longitude and northerly and westerly components of velocity by means of observations carried out in a closed room. It is assumed that the vertical is known from observations of a pendulum and it is shown how dynamic observations of two gyroscopic systems suffice to determine the required quantities. [The possible effects of perturbations of the vertical due to the accelerations of the closed system and due to the departures of the geoid from a spheroidal form are not discussed.] A. H. COOK

529.7

1422. Towards a new definition of the scale of time. J. F. COX. *Ann. Franç. Chronom.*, **6**, 177–82 (*No.* 3, 1951) *In French.*

A general review of the necessity for a new definition of the fundamental unit of time on account of irregularities in the rotation of the earth.

R. A. NEWING

529.7

1423. Reflections on the question of units of time. G. TIERCY. *Ann. Franç. Chronom.*, **6**, 183–91 (*No.* 3, 1951) *In French.*

The effects of the progressive retardation of the earth's rotation is discussed, and it is suggested that other phenomena might be used to define a new astronomical unit of time, e.g. cepheid variables might be regarded as natural Newtonian clocks.

R. A. NEWING

529.786

1424. Atomic clocks and applications to astronomy. H. LYONS. *Astron. J.*, **56**, 119–20 (*Oct.*, 1951).

Very brief accounts of 4 types of quartz crystal (or equivalent) clocks automatically regulated by atomic or molecular vibrations. D. L. EDWARDS

PHYSICS 53

53

1425. On the analysis of transfer of training. L. A. DEXTER AND R. A. THORNTON. *Amer. J. Phys.*, **19**, 538–45 (*Dec.*, 1951).

If what is learned is to be transferable, it must be done in terms of generalized intellectual processes. These processes must be explicitly identified and taught in such a way as to permit students to generalize what is particular and to apply what is general. The selection of curricular material must be done in terms of these processes rather than in terms of a traditional body of facts. Physics, because of its postulational-deductive character, offers an excellent opportunity for this conception of education. A.

53

1426. Laboratory performance tests at the University of Minnesota. C. N. WALL, H. KRUGLAK AND L. E. H. TRAINOR. *Amer. J. Phys.*, **19**, 546–55 (*Dec.*, 1951).

Typical tests in mechanics, electricity, sound and

optics are reproduced and the important phases of the testing programme are described. The detailed statistical analysis of the mechanics performance test points to the need of additional experimentation in this field. A.

53.08

1427. The fundamental problems of experimental physics. J. HOUGH. *Amer. J. Phys.*, **19**, 489–99 (*Dec.*, 1951).

An elementary treatment of the nature of an experiment is given in order to demonstrate the various factors which must be considered in planning an experiment. Particular attention has been paid to the factors on which the accuracy of the final result depends; and it has been found desirable to introduce two new quantities, the reading and experimental limits, which give a measure of the maximum accuracy of a measurement and an experiment, respectively, obtainable with the particular apparatus. A.

53.081

1428. Units and dimensions in physics. C. H. PAGE. *Amer. J. Phys.*, **20**, 1–4 (*Jan.*, 1952).

The equations of physics are often interpreted as purely numerical relations. Endowing the symbols with "dimensional" quality as well as magnitude leads to a simpler, yet rigorous, mathematical structure, and permits changing units by direct substitution. Analysis of the mathematical universe of discourse of physical equations shows also that the four-dimensional l, m, t, q system of units is actually simpler than a three-dimensional system. A.

FUNDAMENTALS 530.1

530.12

1429. Metrical and matter fields. K. FINK. *Comment. Math. Helv.*, **25**, 26–42 (1951).

The Mie–Hilbert formulation of the relation of metrical and matter fields is used to discuss the field equations of general relativity for the spherically symmetric case. Three cases are distinguished. Two give infinite total energy for the universe, the third gives finite negative total energy. The cosmological problem arising when spatial isotropy is imposed on the above is studied. MATHEMATICAL REVIEWS

530.12

1430. The rôle of the three-index symbols in relativity. V. V. NARLIKAR AND K. P. SINGH. *Proc. Nat. Inst. Sci. India*, **17**, 311–22 (*July–Aug.*, 1951).

There is an indeterminateness implicit in the co-ordinates of general relativity. It is shown how it manifests itself when the gravitational effects are measured in a Riemannian field with an auxiliary flat space-time serving as the substratum. We consider New vectors and scalar invariants are considered, couched in terms of certain three-index symbols which are defined in relation to the auxiliary space-time, and it is shown how the intensity of gravitation appears through them. A new derivation of the inverse-square law of gravitation is given, the space-time being virtually flat. The equations used are of a non-metric affine space and the method is one suggested by the role of the three-index symbols in general relativity. A.

530.12

1431. The definition of moving coordinate systems in relativistic theories. E. L. HILL. *Phys. Rev.*, **84**, 1165–8 (*Dec.* 15, 1951).

A kinematic analysis is given of the ambiguities which arise in the definitions of moving reference systems when general transformations are allowed on the space-time variables. It is shown how the classical theory permits an extension to any order of kinematic derivatives. In a relativistic treatment only the step to uniformly accelerated motions is possible in a direct manner. The discussion is limited to one-dimensional motions. A.

530.12

1432. Space at mid-century. R. SCHLEGEL. *Amer. J. Phys.*, 38–49 (*Jan.*, 1952).

The concepts of space which are used in contemporary physics are discussed, and are contrasted with the older concepts associated with Newtonian physics. The effects of uniform motion on space and the simplest, currently accepted relations between space and time are stated. Deviations from three-dimensional orthogonal space as demanded by the general theory of relativity are discussed, with attention to the relative roles of space and time terms in the space-time curvature associated with gravitational fields. The development of cosmological theory, on the basis of general relativity concepts, is briefly indicated. Mach's suggestion for the relation of matter and space is described; more recent speculations relating over-all space and local properties, and the possibility of discontinuity in microscopic space, are noted. The emphasis in the current conception of space on interdependence between space and matter is pointed out. A.

530.12 : 531.18

1433. Verification of the principle of special relativity by a new optical method. A. B. PAL. *Pakistan J. Sci. Res.*, **3**, 1–3 (*Jan.*, 1951).

A narrow beam of parallel rays of light is first refracted through a semi-circular glass slab and then reflected by a number of cylindrical mirrors. It is found that the adjustment of the successive angles of incidence to some proper values makes the optical arrangement so sensitive that a slight change in the angle of the incidence of the first ray produces a large deflection in the path of the final ray. The whole apparatus was set on a horizontal wooden board which was slowly rotated about a vertical axis. The orbital velocity of the earth was supposed to produce a periodic variation in the path of the final ray. There was absolutely no change in the path of the final ray on any occasion. The null result of this optical experiment verifies the Principle of Special Relativity. A.

530.12 : 536.7

1434. On thermodynamics of matter in a static field. N. G. MAJUMDAR. *Bull. Calcutta Math. Soc.*, **43**, 51–5 (*March*, 1951).

Tolman's equilibrium condition $T_0\sqrt{g_{44}} = \text{const.}$ for the proper temp. T_0 is derived independently of

field equations by introducing a space-time generalization of the equation of heat conduction.

R. A. NEWING

530.145 : 535.14

1435. Note on the quantum theory of the Doppler effect for a moving observer. A. VANDERZIEL. Note in *Amer. J. Phys.*, **20,** 51–2 (*Jan.*, 1952).

The formula is derived from considerations of the conservation of energy and momentum without using relativistic time dilatation.

R. A. NEWING

530.145

1436. Axiomatics as a method for the formation of physical theories. G. FALK. *Z. Phys.*, **130,** 51–68 (*No.* 1, 1951) *In German.*

The algebraic structure of classical mechanics is exhibited in terms of a commutative ring for which is defined a process of Poisson bracket formation; a non-commutative ring gives the structure of non-relativistic quantum mechanics; new theories could be developed by modifying the axioms defining bracket formation. The structure of relativistic quantum mechanics is related to that of Maxwell's equations.

R. A. NEWING

530.145

1437. A note on the quantum rule of the harmonic oscillator. L. M. YANG. *Phys. Rev.*, **84,** 788–90 (*Nov.* 15, 1951).

The purpose of the present note is to show, with the aid of an elementary example, that the commutation rules, which are usually given the rule of postulates in quantum mechanics, are in fact not arbitrary, provided that a more stringent definition of the Hilbert space and a strict expansion theorem are adopted.

A.

530.145

1438. Approximation methods in the theory of scattering. M. L. GOLDBERGER. *Phys. Rev.*, **84,** 929–38 (*Dec.* 1, 1951).

The quantum theory of scattering is discussed from the point of view of a time independent formulation. A detailed discussion of the replacement of the ordinary integral equation of scattering by two others is given together with a discussion of the desirability of this procedure both from a physical and mathematical point of view. Variational formulations of these equations are given and their accuracy is indicated by comparison with examples for which exact solutions are known. An exactly soluble problem given by Blatt is treated from the standpoint of the present paper. A formal solution of the general scattering problem is developed and illustrated with Blatt's example.

A.

530.145

1439. Attempts to relate the constants λ (cosmological constant) and μ_0 (mass of the photon). M.-A. TONNELAT. *J. Phys. Radium,* **12,** 829–32 (*Nov.*, 1951) *In French.*

A formal relation $4\pi^2\mu_0^2 + \lambda h^2 = 0$ is suggested by comparison of the equations of propagation of a Maxwell field in a Riemann space of constant curvature and of a photon of non-vanishing mass in Euclidean space. A physical basis for such a relation has not been found.

R. A. NEWING

530.145

1440. On two classes of "observation operators." "Operators of observation" and the theory of information. R. VALLÉE. *C.R. Acad. Sci.* [*Paris*] **233,** 1350–1 (*Nov.* 26); 1428–30 (*Dec.* 3, 1951) *In French.*

Describes two kinds of "observation operators" relating the response observed to the stimulus applied, one operating in space-time co-ordinates, the other in the space of the Fourier transform. Examples of each are well known. A mixed product operator useful in information theory is defined and an expression is derived for the maximum information obtainable when given observation operators are involved.

R. H. DALITZ

530.145 : 539.153

Relativistic corrections to the Lamb shift. *See Abstr.* 2072

530.145

1441. Vacuum polarization as the origin of a limitation of field for the electron. E. BAGGE. *Z. Phys.*, **130,** 650–5 (*No.* 5, 1951) *In German.*

With a vacuum polarization represented by the dielectric constant $A/(2mc^2 - e\phi)^2$, the e.s. potential ϕ is $e/(r_0 + r)$ $(r_0 = e^2/2mc^2)$ and the electrostatic self energy is $A/4mc^2$.

R. H. DALITZ

530.145

1442. On the positron theory of vacuum. Y. KATAYAMA. *Progr. Theor. Phys.*, **6,** 309–21 (*May–June*, 1951).

The density matrix for the vacuum in constant e.m. field (according to positron theory) is obtained using the Fock proper time method. The non-gauge-invariant infinite terms are subtracted by a procedure proposed here, leaving a gauge invariant result. This subtraction procedure needs only slight modification for arbitrary external field.

R. H. DALITZ

530.145

1443. On the formalism of linear field-theories. II. H. STEINWEDEL. *Z. Naturforsch.*, **6a,** 519–22 (*Oct.*, 1951) *In German.*

The Lagrangians and commutation relations are given for the generalized field theories studied previously [Abstr. 6021 (1951)]. Quantization of the Bose-fields presents no difficulties, but quantization of the Fermi-fields is not possible in the framework of the present formalism.

R. H. DALITZ

530.145

1444. On the quantum theory of reciprocal fields and the correspondence principle. J. RAYSKI. *Proc. Phys. Soc.* [*Lond.*] *A*, **64,** 957–68 (*Nov.*, 1951).

A method of quantization of non-local fields whose interaction is expressible by means of integral equations is given. The *S*-matrix is constructed by Yang's method. The non-local field theory is free of the usual convergence difficulties. It is possible to satisfy generally either the postulate of reciprocity or the postulate of correspondence, but it seems impossible to satisfy both principles simultaneously.

A.

530.145

1445. An equation for a particle with two mass states and positive charge density. H. J. BHABHA. *Phil. Mag.*, **43,** 33–47 (*Jan.*, 1952).

A relativistic wave equation in the canonical form is given which describes a particle having two different

rest masses. In one mass state the particle has a spin 3/2, in the other a spin 1/2. The free charge density is positive definite so that the equation can be quantized in the usual manner in accordance with the exclusion principle. The equation is irreducible. This example establishes the principle that irreducible multi-mass equations exist which can be used to form the basis of a physical theory along the usual lines, contrary to the general prevalent view. A.

530.145

1446. On the question of a difference in mass between electron and positron. H. SALECKER. *Z. Naturforsch.*, **6a**, 484–6 (*Sept.*, 1951) *In German.*

In the present frame of quantum field theory, a difference in mass between electron and positron can arise from their β-decay coupling, if there does not exist a negative proton. The positron self-energy due to this coupling is calculated using regulators, and compared with the corresponding e.m. self-energy of the electron and positron. R. H. DALITZ

530.145

1447. A new covariant auxiliary condition for quantum electrodynamics. F. J. BELINFANTE. *Phys. Rev.*, **84**, 644–7 (*Nov.* 15, 1951).

The condition is assumed to be valid for all states occurring in nature. Such special assumptions as the condition for a "photon vacuum" then become superfluous. The meaning of the new auxiliary condition is that the expectation value of the electromagnetic field is equal to that of the retarded field from charged matter: "All light has once been emitted." If in some discussion of properties of a particular photon the source of that particular photon is to be ignored (without denying its existence), the covariant auxiliary condition can be ignored in such a special case, being replaced by an appropriate "practical" boundary condition. In self-energy calculations a "photon vacuum" condition is sometimes used. Such approximation gives correct results up to second but not to fourth powers of e. A.

530.145

1448. The energy density tensor in gauge-independent quantum electrodynamics. F. J. BELINFANTE. *Phys. Rev.*, **84**, 648–53 (*Nov.* 15, 1951).

In Heisenberg representation two different definitions of an energy density tensor are given for gauge-independent quantum electrodynamics. Both tensors lead to the same total energy and momentum, if the interaction is assumed to vanish at $t = -\infty$. They both satisfy conservation laws. The tensor character of the first one is proved, and the tensor character of the second one is manifest. The first tensor is obtained by analogy with the result of a derivation of the energy density tensor as source of the gravitational field from general-relativistic considerations in manifestly covariant quantum electrodynamics, with subsequent omission of the "phantom terms" containing the redundant variables of this theory. The second tensor has the advantage of admitting a simple covariant subtraction of its vacuum value, and of simplifying even further by use of the new covariant auxiliary condition proposed by the author (preceding abstract). Its disadvantage, though, is the impossibility of direct physical interpretation, as in Heisenberg representation it is not expressed in terms of field variables in Heisenberg representation. The inconclusiveness of an argument for possible equality of the two tensors is discussed. Both tensors contain the usual self-interaction effects, and the problem is posed of how to eliminate these effects. A.

530.145

1449. Reversibility of quantum-electrodynamics. S. WATANABE. *Phys. Rev.*, **84**, 1008–25 (*Dec.* 1, 1951).

Aims at re-establishing the reversibility of classical electrodynamics in terms of the "expectation values" given by quantum-electrodynamics. The reversibility requirement combined with the charge conjugation necessitates that charged fields should obey certain types of statistics. However, the reversibility requirement as such does not determine the statistics, showing that it is the requirement of charge-invariance that has the power to determine the statistics of charged fields. A new interpretation will be given to the old problem concerning the conflict of electromagnetic reversibility *v.* "retarded" potential. Four different kinds of tensors, four different kinds of spinors (pseudospinors), bi-spinors (eight-component spinors) and bi-tensors are introduced as useful representation vectors of the entire congruent group including spatial and temporal inversions. A.

530.145

1450. Eigenvalue problem in quantum electrodynamics. M. NEUMAN. *Phys. Rev.*, **85**, 129–33 (*Jan.* 1, 1952).

The eigenvalue problem in quantum electrodynamics is discussed from the point of view of the Fredholm theory of integral equations. Starting with positron theory—the theory of a quantized Dirac field interacting with an external field only—the external potentials are replaced by bare photon fields. To insure causality the photon operators are ordered in time. Certain integral equations for the Fredholm minors constructed on the Feynman kernel are taken to be the equations for the wave functions of n particle systems. An expansion in interaction patterns rather than the coupling constant is indicated. The one particle problem is treated in the first pattern approximation. Procedures proposed by Snyder and Snow and the mass renormalization scheme are discussed in this connection. Finally a purely formal derivation of the Bethe–Salpeter equation for the two-body problem in the lowest pattern approximation is given. A.

530.145

1451. Fermi statistics for a system with interaction. H. KOPPE. *Z. Naturforsch.*, **6a**, 517–19 (*Oct.*, 1951) *In German.*

A calculation of the specific heat at low temperatures yields the same result as for free particles, provided a new value for the energy-density of states is inserted. G. J. KYNCH

530.145

1452. On a general variational principle in theoretical physics. T. KAHAN AND G. RIDEAU. *C.R. Acad. Sci.* [*Paris*] **233**, 849–52 (*Oct.* 15, 1951) *In French.*

A variational principle given for the solution of the inhomogeneous equation of a symmetrical operator is

illustrated by deriving as special cases the principles given by Schwinger [Abstr. 5958 (1949)] and by Kohn [Abstr. 1511 (1949)]. R. H. DALITZ

530.145

1453. Renormalization theory of the interactions of nucleons, mesons, and photons. J. C. WARD. *Phys. Rev.*, **84**, 897–901 (*Dec.* 1, 1951).

A general programme for the removal of divergencies from the theory of the interactions of nucleons, mesons and photons is formulated. It is shown that the procedure is equivalent to renormalization of the constants of the theory. A.

530.145

1454. A phenomenological theory of the Lamb shift and of anomalous magnetic moments. F. J. BELINFANTE. *Phys. Rev.*, **84**, 949–56 (*Dec.* 1, 1951).

If one assumes that self-interactions do not exist and can be ignored, the explanation of the anomalous magnetic moments of proton and electron and the Lamb shift require new types of interaction between protons, photons and electrons. A theory with such additional interactions is here developed in gauge-independent form, thus avoiding longitudinal and scalar photons throughout. The covariance of the formalism is proved. The resulting modification of Maxwell's equations for charge elementary particles in the vacuum involves only the introduction of an intrinsic polarization and magnetization of elementary particles, so that these equations for the vacuum now take the familiar form of the macroscopic Maxwell equations in matter. A further modification of the Dirac equation for electrons and protons involves the introduction of a delta-function interaction between them, opposite in sign to the Coulomb interaction. It is indicated how one can derive an energy density tensor for this theory. It is then shown how this formalism explains the anomalous moments and the Lamb shift. The three new interaction constants are adjusted to the experimental data. The dependence of the Lamb shift on the quantum numbers automatically comes out to be nearly the same and the dependence on the atomic number to be exactly the same as in the theory of Bethe, French and Weisskopf. A.

530.145

1455. Limitations on mass changes of scattered nucleons. G. BREIT AND H. M. JONES. Letter in *Phys. Rev.*, **84**, 1054 (*Dec.* 1, 1951).

If nucleons could change mass on collision, the angular relations of the collision would be modified. It is considered to what extent present resolution in collision experiments using coincidence methods excludes such mass change. R. H. DALITZ

530.145

1456. Radiation reaction in relativistic motion of a particle in a wave field. E. GORA. *Phys. Rev.*, **84**, 1119–23 (*Dec.* 15, 1951).

An approximate solution of the equations of motion of Dirac's classical theory of pointlike particles is obtained for a particle in the field of a plane wave, under the assumption that the radiation reaction terms in these equations can be considered as small. The appearance of runaway terms in this solution is avoided by letting the interaction set in gradually. Considerable simplification is achieved by restriction to the domain of high relativistic energies where the transfer of energy and momentum from the wave to the particle appears to be mainly due to radiation reaction. A quantitative discussion of the conditions of applicability of the formulae obtained is made possible by the assumption that there is correspondence between a photon and a classical wave train of finite length. This assumption leads to the conclusion that the classical formulae can be valid for arbitrarily high energies. An estimate of a lower limit for the duration of the interaction between particle and wave train yields an expression which resembles formulae for lifetimes of unstable particles both in its dependence upon fundamental constants and in its increase with the energy involved in the process. A.

530.145

1457. Charge-renormalization accompanying radiative corrections. M. DEMEUR. Letter in *Nature [Lond.]* **168**, 1037–8 (*Dec.* 15, 1951).

Discusses absence of charge renormalization in some calculations of radiative corrections using "bound interaction representation." For an external magnetic field, commutator properties are known explicitly, so that for this case calculations may be carried through completely in this representation. R. H. DALITZ

530.145

1458. Elementary particles. E. FERMI. *London: Oxford University Press* (1951) 110 *pp.*

"Attempts to make accessible to . . . students and . . . experimental physicists some of the most significant results of the field theories of elementary particles that can be understood, at least in a semi-quantitative way, without excessive mathematical apparatus."

530.145

1459. A note on the trace of the product of Dirac's matrices. L. M. YANG. *Phil. Mag.*, **42**, 1333 (*Nov.*, 1951).

530.145

1460. A canonical field theory with spinors. J. HELLER AND P. G. BERGMANN. *Phys. Rev.*, **84**, 665–70 (*Nov.* 15, 1951).

A general field theory in covariant form has been constructed, which incorporates the usual covariant generalization of Dirac matrices. The field equations are derived from a Lagrangian that is a second-order differential covariant (a scalar density of weight 1) constructed in the covariant spinor formalism by the same method that in Riemannian geometry leads to the curvature tensor. It is possible to show that, in spite of the apparently greater wealth of geometrical elements, this theory is completely equivalent to the general theory of relativity. The field equations satisfy the usual differential identities and, in addition, "spin" identities there are four "strong" conservation laws which can be used to obtain equations of motion for singularities. Since it is not known at present whether the equivalence with the theory of relativity may not be lost in the process of quantization, eventual quantization is considered desirable

and the theory has here been converted into the canonical form. A.

530.145

1461. A canonical transformation in the theory of particles of arbitrary spin. W. A. HEPNER. *Phys. Rev.*, **84**, 744–9 (*Nov.* 15, 1951).

Canonical transformation between the β operators and certain components of the spin-tensor yields explicit expressions for the latter. The transformation is used to deduce general consequences that simplify the derivation of commutation relations. It can also be applied with advantage to construct free particle solutions of the wave equation. A.

530.145

1462. Scattering of radiation by electrons in relativistic quantum mechanics. O. HALPERN AND H. HALL. *Phys. Rev.*, **84**, 997–1008 (*Dec.* 1, 1951).

The theory of the scattering of radiation by Dirac electrons is revised and extended. Assuming negative energy states unoccupied, a formula for the cross-section of coherent scattering of very hard quanta is derived. It is, furthermore, shown that the previously claimed and accepted one-to-one correspondence of the matrix elements for the cases of free or occupied negative energy states is generally untrue. It can be proved that for moderately small quanta the cross-sections of coherent and incoherent scattering by bound electrons are approximately the same in the case of unoccupied negative energy states and in the pair theory proper. Characteristic differences are shown to exist for very hard radiation. The historical development of the problems here treated is also discussed. A.

530.145

1463. Remarks concerning the existence of the Foldy–Wouthuysen transformation. H. S. SNYDER. Letter in *Phys. Rev.*, **84**, 1052 (*Dec.* 1, 1951).

Notes that a unitary transformation which removes all odd operators from the Dirac equation does not generally exist, so that the power series expansion given by Foldy and Wouthuysen [Abstr. 5526 (1950)] for such a transformation is not always convergent. R. H. DALITZ

530.145

1464. A special method for solving the equation of meson in the field of plane electromagnetic radiation. S. GUPTA. *Bull. Calcutta Math. Soc.*, **43**, 8–12 (*March*, 1951).

Using β-matrix formalism, an exact solution is found for the wave function of a meson in the external field of a plane e.m. wave. The induced current vector is calculated and compared with that for the Dirac electron. R. H. DALITZ

530.145

1465. The multipoles of the meson field. W. FRANZ AND L. TEWORDT. *Z. Phys.*, **130**, 457–67 (*No.* 4, 1951) *In German.*

The general multipole solutions for Kemmer mesons in a central electrostatic field are deduced simply. For every value of the angular momentum and its z-component one finds in the case of vector mesons 1 longitudinal and 2 transverse multipoles, corresponding to the 3 orientations of the spin 1, and for a scalar meson only 1 longitudinal multipole. The solutions of the spin equations for spin 1 are investigated systematically and are related to "Laplace spherical harmonics with spin 1." W. J. SWIATECKI

530.145

1466. Contribution to the covariant study of the nuclear field: analysis of the nucleon-nucleon scattering processes. C. MARTY. *Ann. Phys.* [*Paris*] **6**, 830–94 (*Sept.–Oct.*, 1951) *In French.*

A dissertation on nucleon-nucleon collisions: the experimental data and the theory of static nuclear forces are surveyed. The cross-section for nucleon-nucleon scattering by exchange of one meson is calculated from the S-matrix for all meson fields and interactions, the "non-static" effects being retained. No single field nor mixture of two fields agrees with 90 MeV n–p scattering—however, these methods are inadequate for psc. meson theory. R. H. DALITZ

530.145

1467. On the Tomonaga method for intermediate coupling in meson field theory. R. H. DALITZ AND D. G. RAVENHALL. *Phil. Mag.*, **42**, 1378–83 (*Dec.*, 1951).

The iteration method of Svartholm is employed to improve the approximate wave function used by Tomonaga to describe the scalar meson field of an isolated nucleon. It is found that this wave-function of Tomonaga is surprisingly good, even in the region of intermediate coupling, the change in coupling parameter for given energy being at most 3% after the first iteration. A.

530.145

1468. On a phenomenological approach to meson production in nucleon-nucleon collisions. E. A. POWER. *Proc. Roy. Soc. A*, **210**, 85–98 (*Dec.* 7, 1951).

The validity of certain phenomenological approaches to spin zero meson production in nucleon-nucleon collisions is considered. It is shown that, to first-order perturbation theory, a method analogous to the distorted wave approximation is valid. Comparison is made with a bremsstrahlung-like calculation which, for neutral mesons with non-derivative coupling to the spinor field, gives no production, since the nucleon recoil is neglected. Application of the distorted wave approach to neutral meson production in proton-neutron collisions, and comparison with the results for production of charged mesons in proton-proton collisions is sketched. Results are quoted for simple inverse processes. A.

530.145

1469. A relativistic equation for bound-state problems. E. E. SALPETER AND H. A. BETHE. *Phys. Rev.*, **84**, 1232–42 (*Dec.* 15, 1951).

The relativistic S-matrix formalism of Feynman is applied to the bound-state problem for two interacting Fermi–Dirac particles. The bound state is described by a wave function depending on separate-times for each of the two particles. Two alternative integral equations for this wave function are derived with kernels in the form of an expansion in powers of g^2, the dimensionless coupling constant for the interaction. Each term in these expansions gives Lorentz-invariant equations. The validity and physical significance of these equations is discussed. In

extreme non-relativistic approximation and to lowest order in g^2 they reduce to the appropriate Schrödinger equation. One of these integral equations is applied to the deuteron ground state using scalar mesons of mass μ with scalar coupling. For neutral mesons the Lorentz-invariant interaction is transformed into the sum of the instantaneous Yukawa interaction and a retarded correction term. The value obtained for g^2 differs only by a fraction proportional to $(\mu/M)^2$ from that obtained by using a phenomenological Yukawa potential. For a purely charged meson theory a correction term is obtained by a direct solution of the relativistic integral equation using only the first term in the expansion of the kernel. This correction is due to the fact that a nucleon can emit, or absorb, positive and negative mesons only alternately. The constant g^2 is increased by a fraction of $1 \cdot 1(\mu/M)$ or 15%. A.

530.145

1470. Equivalence of the S-matrix in different representations. L. M. YANG. Letter in *Phys. Rev.*, **84**, 1258–9 (*Dec.* 15, 1951).

Shows that the *S*-matrix calculated in arbitrary representation is equivalent to the Dyson *S*-matrix, which is in interaction representation. R. H. DALITZ

530.145

1471. Principle of detailed balance. F. COESTER. Letter in *Phys. Rev.*, **84**, 1259 (*Dec.* 15, 1951).

The behaviour of the *S*-matrix elements under reversal of the time axis is studied, and it is shown that the transition probability for a given process equals that of its inverse, the inverse process being that obtained by reversal of the time axis.

R. H. DALITZ

530.145

1472. Schrödinger's theory of dispersion by Born's method of perturbations. M. A. ROCA. *Rev. Soc. Cubana Cienc. Fis. Mat.*, **2**, 136–41 (1949) *In Spanish.*

The Schrödinger formulae for the dispersion of an electromagnetic wave by a quantum mechanical system are derived. MATHEMATICAL REVIEWS

530.145

1473. Perturbation methods in the quantum mechanics of *n*-electron systems. E. M. CORSON. *New York, Hafner Publishing Company* (1950) xi + 308 *pp.*

530.145

1474. Fundamental properties of Hamiltonian operators of Schrödinger type. T. KATO. *Trans Amer. Math. Soc.*, **70**, 195–211 (1951).

It is shown that the Hamiltonian for a finite set of non-relativistic quantum-theoretical particles with interaction determined by a suitable potential energy is hypermaximal symmetric. The energy levels therefore exist and are unique. This was previously known only in some special cases. The present method establishes the character of the operator by Hilbert space techniques not involving the determination of the spectral resolution.

MATHEMATICAL REVIEWS

530.145

1475. The forced vibrations of an harmonic oscillator according to quantum theory. G. LUDWIG. *Z. Phys.*, **130**, 468–76 (*No.* 4, 1951) *In German.*

An exact solution of this problem is found for an arbitrary external force $F(t)$. This is checked by a calculation using time-dependent perturbation theory.

G. J. KYNCH

530.145

1476. The calculation of partition functions by means of Laplace transforms. H. KOPPE. *Ann. Phys.* [*Lpz.*] **9**, 423–8 (*No.* 8, 1951) *In German.*

It is shown that the Laplace transform of the partition function of an atomic system is related to the Green's function of the Schrödinger equation which defines the stationary states. The method is used to derive partition functions for a particle in a box and for a rigid rotator (Mulholland). An asymptotic expansion which may be useful in general cases is obtained. J. R. MADDOX

530.145

1477. Wave functions in momentum space. E. E. SALPETER. *Phys. Rev.*, **84**, 1226–31 (*Dec.* 15, 1951).

The integral equation, satisfied by the momentum-space wave function $\phi(p)$ for a non-relativistic two-body problem with a phenomenological central interaction potential, is solved by means of an iteration method. A general prescription is given for finding suitable trial wave functions, which depend on some adjustable parameters. Reasonable values for these parameters are found by iteration of the wave function for particularly convenient values of the momentum. Successive iterations, giving better approximations $\phi_n(p)$ for $\phi(p)$, are carried out in a form suitable for numerical work. Besides $\phi_n(p)$, approximations are obtained for (*a*) the binding energy for certain bound states, and (*b*) the phase shifts for scattering problems. For scattering at fairly low energies reasonable approximations are obtained with the same method both for weak and for fairly strong potentials. Extensions of the method are discussed for (*a*) two-body problems including tensor forces, (*b*) simple three-body problems, and (*c*) a relativistic equation for the two-body problem. A.

530.145

1478. Perturbation theory and configuration space methods in field theory. S. SCHWEBER. Letter in *Phys. Rev.*, **84**, 1259–60 (*Dec.* 15, 1951).

Reports progress on investigation (in Schrödinger representation) of one- and two-body problems in sc. and psc. meson theory, making the approximation (not equivalent to perturbation theory) of neglecting all but the first three Fock wave-functions.

R. H. DALITZ

530.145

1479. Motion of an electron in a perturbed periodic potential. E. N. ADAMS, II. *Phys. Rev.*, **85**, 41–50 (*Jan.* 1, 1952).

Wannier's theorem concerning the motion of an electron in a perturbed periodic potential is generalized so as to take into account transitions between energy bands. The generalized form of the theory is placed on a rigorous quantum-mechanical foundation and the basic approximation of Wannier's form of the theorem elucidated. A compact matrix formulation is developed which permits the multiband character of the formalism to be handled expeditiously. It is shown that corrections to Wannier's approximate

equation of motion arising from variations of the potential within a unit cell require a multiband formalism, since these corrections affect the motion primarily by causing transitions between bands. The correction terms are expressed in such a form that they may be conveniently treated as perturbations. A generalized form of Wannier's theorem is presented in which the perturbing potential may depend upon both the co-ordinate and momentum of the electron. The special case that the perturbative potential is due to slowly varying combined electric and magnetic fields is discussed in detail. Applicability to the problem of the electron-phonon interaction is discussed briefly. A.

530.145.6

1480. Relativistic quantum mechanics. II. W. Wessel. *Z. Naturforsch.*, **6a**, 473–7 (*Sept.*, 1951) *In German.*

The theory developed in a previous paper [Abstr. 3780 (1950)] encounters the difficulty, found also in related theories, that all regular mass operators have an infinite number of special values of small magnitude. Types of mass operator free from this objection are discussed. P. M. DAVIDSON

530.145.6

1481. Erratum: Theorem on the invariant formed from four Dirac wave functions. L. Michel. *J. Phys. Radium*, **12**, 951 (*Dec.*, 1951) *In French.*

See Abstr. 3341 (1951).

530.145.6

1482. Singular solutions of Klein–Gordon and Dirac equations, taking account of an external electric field. M. Demeur. *Physica*, **17**, 933–7 (*Nov.–Dec.*, 1951) *In French.*

See Abstr. 4112 (1951). The singular solutions relative to particles of spin 0 and $\frac{1}{2}$ placed in a uniform and constant electric field are given without approximation. Integral representations are given for Δ, Δ_F, S, S_F. A.

530.162

1483. On a transformation of the integral term of the Boltzmann equation. J. J. Bernard. *C.R. Acad. Sci.* [*Paris*] **233**, 1348–50 (*Nov.* 26, 1951) *In French.*

With the variables given here, the Boltzmann integral has a form especially convenient when there exists a preferred axis. For the case of hard spheres, the kernel is expressed in these variables.

R. H. DALITZ

530.162

1484. Brownian fluctuations in galvanometers and galvanometer amplifiers. R. V. Jones and C. W. McCombie. *Philos. Trans A*, **244**, 205–230 (*No.* 881, 1951).

Previous work is summarized and a simple treatment given of the fluctuations of a galvanometer with negligible inductance in its circuit; the correlation function of the random force is used, not the frequency spectrum. Both molecular bombardment of the suspended mirror and Johnson noise in the circuit resistance are considered, and a comment is made on why the coexistence of these two effects does not increase the r.m.s. deflection above its equipartition value. It is further shown by an exact random force calculation that the presence of an appreciable inductance in the galvanometer circuit does not change the r.m.s. values of deflection and angular velocity. The same result is obtained by a statistical mechanical argument based on the assumptions already implicit in the application of the equipartition principle to, say, a suspended mirror. Expressions are obtained for the magnitude and correlation function of the Brownian fluctuations of a galvanometer amplifier with two galvanometers of arbitrary periods and damping; these expressions are in terms of the periods and damping constants of the two galvanometers, the mechanical damping of the primary galvanometer and the resistance of the primary circuit. A method of finding the magnitude and correlation function of the fluctuations from a record of the throw of the secondary galvanometer consequent on passing a known charge through the primary is suggested. The magnitude of the Brownian fluctuations in a galvanometer amplifier was determined experimentally. The effects of external disturbances were reduced till the changes in zero, including overall drift, caused by them in 30 min (say 1 000 times the response time) were much less than the r.m.s. Brownian deflection. The methods used to determine the quantities in the theoretical expression for the r.m.s. Brownian deflection are described. Various conditions of damping were used and the average ratio of experimental to theoretical r.m.s. deflections was found to be 100·0% with $\pm 1 \cdot 1\%$ standard error. An appendix describes the verification for the case of the galvanometer amplifier of Rice's formulae for the number of zeros and number of points of zero slope on the record of a one-dimensional Gaussian random process. A.

530.162

1485. Order–disorder statistics. IV. A two-dimensional model with first and second interactions. C. Domb and R. B. Potts. *Proc. Roy. Soc. A*, **210**, 125–41 (*Dec.* 7, 1951).

For Pt III, see Abstr. 6760 (1951). The statistics of the rectangular lattice with first and second neighbour interactions is discussed in detail. Several terms of the low-temperature series for the partition function are obtained for the case when the interactions are ferromagnetic, and for the "no-field" lattice reciprocal transformations are used to transform to series valid for antiferromagnetic interactions. The transition points for different signs and magnitudes of the interaction energies are estimated. An exceptional value of the ratio of the first and second interaction energies is found for which the lattice has no transition point and long-range order offers no energy advantage. The series are used to predict the behaviour of the first derivatives of the partition function, and the results are applied to models of a ferromagnet, binary alloy, antiferromagnet and adsorbed monolayer.

530.162 : 536.7

1486. Generalized statistical mechanics. P. G. Bergmann. *Phys. Rev.*, **84**, 1026–33 (*Dec.* 1, 1951).

A start is made toward the development of a statistical mechanics that will be suited to the treatment of dynamic changes in thermodynamic systems and which, at the same time, will be in the appropriate form for a relativistically invariant theory. The formal device consists of making the time coordinate

one of the canonical variables. As a result, stationary ensembles no longer occupy a privileged position among all conceivable Gibbs ensembles, and it becomes necessary to redefine and to reformulate most statistical and thermodynamic concepts. This has been done with the concept of a canonical ensemble, with entropy, temperature, heat flux and performance of work. With a suitable definition of the entropy of an individual system, a new formulation of the *H*-theorem is provided, which in turn leads to a formulation of the Second Law. A.

GENERAL MECHANICS . MECHANICS OF SOLIDS 531

531.22

1487. The knotty masspoint *versus* the rigid tinplate. D. A. NAYMIK. *Amer. J. Phys.*, **19**, 519–22 (*Dec.*, 1951).

Describes an experiment called "The tinplate experiment" which is slightly more difficult than "The force board experiment," and is intended to bridge the gap between it and the "Study of forces acting on a crane" experiment. A.

531.231/.38

1488. The moment of inertia and the period of the rocking of an elliptic band. J. SATTERLY. *Amer. J. Phys.*, **19**, 511–13 (*Dec.*, 1951).

The radius of gyration of a thin, elliptical band of uniform line density is given (*i*) by direct evaluation; (ii) from the point of view that the band represents the interval between adjacent ellipses of semiaxes *a* and *b*; and (iii) by taking the band between two confocal ellipses. Values of the radii of gyration for several elliptic bands are computed from the three points of view. Experiments in which elliptic bands of brass and glass were rocked on glass plates and on suspended knife-edges gave agreement within 5% of the computed radii of gyration. A.

531.252

1489. A note on elastic surface deformation. M. KORNHAUSER. *J. Appl. Mech.*, **18**, 251–2 (*Sept.*, 1951).

Surface deformation of elastic bodies having the same modulus is treated by the standard texts on elasticity, but the applicability of the solution is limited to the range of the tables of coefficients presented. This note extends the tables to cover the range that applies to bodies having one principal curvature much larger than the other. Some inaccuracy in the tables in current use also is noted. A.

531.3

1490. Completion of a study on stability. M. PARODI. *J. Phys. Radium*, **12**, 665–7 (*June*, 1951) *In French.* See Abstr. 3793 (1950).

531.66

1491. Shapes of craters formed in plaster of Paris by ultra-speed pellets. J. S. RINEHART AND W. C. WHITE. *Amer. J. Phys.*, **20**, 14–18 (*Jan.*, 1952).

Observations have been made on the craters produced in plaster of Paris targets by steel pellets that weighed 2 g and impacted at a velocity of 2·5 km/sec and by aluminium pellets that weighed $\frac{2}{3}$ g and impacted at a velocity of 4·7 km/sec. The angle of impact was varied from normal incidence to 75°. For angles of incidence between 0° and 45°, the mouth of the crater was substantially circular. At 60°, it had roughly the shape of an arrowhead. At 75° obliquity, the pellet ricocheted and produced an elliptical crater. The area of the mouth of the crater in every case was many times the area of the impacting particle. The craters were characterized by a large bowl-shaped excavation from $\frac{1}{2}$ in to 1 in. in depth with a shaft that extended a few inches into the plaster and whose area was approximately that of the pellet. The volumes of the holes have been measured and related to the impacting energy and momenta of the respective pellets. A.

MECHANICAL MEASUREMENTS 531.7

531.713

1492. A new comparator of high precision for the measurement of line standards of length. J. S. CLARK, L. O. C. JOHNSON and V. W. STANLEY. *J. Sci. Instrum.*, **28**, 357–64 (*Dec.*, 1951).

A description is given of a new 1 m comparator having two heat-insulated tanks designed to contain line standards of length and to bring them in turn under a pair of micrometer microscopes rigidly fixed at a distance apart equal to the nominal length of the standards to be compared. The instrument can be used (*a*) to compare the lengths of two standards placed side by side in the same tank and at nominally the same temperature or (*b*) to determine the coefficients of thermal expansion of the materials of which reference standards of length are usually made, by having one standard in one tank and maintaining its temperature constant whilst the temperature of the standard in the other tank is varied. The instrument embodies a number of improvements designed to eliminate all foreseen sources of systematic errors. Results are given which indicate that line standards of length can be measured on the comparator with an accuracy approaching one part in ten millions and that, over a range of about 30°C, mean coefficients of expansion of the order of 10^{-5} per 1°C can be determined with an accuracy of about one-tenth of 1%. A.

531.717

1493. Beta-ray thickness gauges for industrial uses. K. FEARNSIDE. *J. Brit. Instn Radio Engrs*, **11**, 361–6 (*Sept.*, 1951).

The design of a β-ray source (max. strength 5 mC), ionization chamber and feed-back amplifier are outlined, and the main causes of error in industrial applications are explained: these include statistical errors, variation of high resistance and changes in density of air between source and chamber.

F. T. FARMER

531.76

1494. Accelerometers and pendulum levels. M. FERRY. *Ann. Franç. Chronom.*, **6**, 237–44 (*No.* 3, 1951) *In French.*

Small accelerometers for recording the 3 directional

components over the range $\pm 0{\cdot}5$ to ± 20 g are described. They consist of a spring-loaded mass, the deflections of which are recorded with an optical lever. The natural frequency of the 10 g instrument is 100 c/s. A small instrument for accurately indicating the vertical, for measuring small slopes or longitudinal accelerations of up to $0{\cdot}35$ g consists of a pendulum suspended vertically, the deflection of which is recorded with a system of 7 tiny optical levers. Damping is provided with a screw-controlled leak. H. J. H. STARKS

531.787

1495. A sensitive differential manometer. J. M. Los and J. A. Morrison. *Rev. Sci. Instrum.*, **22**, 805–9 (*Nov.*, 1951).

Hg surfaces in two arms of the manometer form plates of condensers connected to two nearly identical oscillator circuits. A change in pressure produces a change in the beat frequency of the oscillators which is measured by comparison on an oscilloscope with the output of an audiosignal generator. For $0 < \Delta p < 0{\cdot}02$ cm an accuracy of $0{\cdot}1$ to $0{\cdot}2$ microns of Hg is obtained. For Δp between $0{\cdot}02$ cm and the maximum measurable with the manometer (approximately $0{\cdot}25$ cm) the accuracy appears to be $0{\cdot}1\%$ or better. A.

531.787.2

1496. A new all-glass membrane manometer. A. Kabesh and R. S. Nyholm. *J. Chem. Soc.* (1951) 3252–3 (*Nov.*).

531.787.7

1497. Determination of mercury level in a steel-tube manometer. R. Meakin. *J. Sci. Instrum.*, **28**, 372–3 (*Dec.*, 1951).

The instrument functions by measuring the absorption by the tube and the mercury of γ-rays from a small Ra source. The indicator is a cathode-ray tube. The unit is mains-operated and determines the level of the mercury to an accuracy of $\pm 0{\cdot}5$ mm. A.

531.79 : 621.396.6 : 620.178.4

1498. A mechanical shock tester for instruments and electronic apparatus. C. T. Morrow. *J. Acoust. Soc. Amer.*, **24**, 26–8 (*Jan.*, 1952).

A mechanical shock tester of the free-fall type has been designed to produce high accelerations in the form of a square wave. The apparatus is described, and the logical considerations which were used as design parameters are explained. Particular attention is paid to the relation between the shocks an equipment is likely to receive in practice and the optimum type of test apparatus. A.

MECHANICS OF FLUIDS 532

532.137

1499. A new surface viscometer. W. E. Ewers and R. A. Sack. Letter in *Nature* [*Lond.*] **168**, 964 (*Dec.* 1, 1951).

A method which is capable of mathematical interpretation has been developed for the measurement of the viscosity of surface films. T. C. TOYE

532.137

1500. The measurement of the viscosity of highly viscous plastic mixes at high rates of shear. J. J. Benbow. *Brit. J. Appl. Phys*, **2**, 359–63 (*Dec.*, 1951).

Viscosity measurements on very viscous pastes at high rates of shear present special difficulties. It has been found that the pendulum viscometer can be used where the more conventional types of viscometer fail. This paper describes the construction of an instrument suitable for the testing of pastes with viscosities of several hundred poises at rates of shear of from 5 000 to 25 000 reciprocal seconds. The average rise of temperature resulting from the work done on such a paste is calculated to be of the order of 13°C at the highest rate of shear. The errors introduced by the change in linear velocity of the pendulum as it passes through the paste and the variation in velocity with the distance from the point of suspension are shown to be negligible in comparison with that arising from the temperature change. Typical results are presented and it is shown that the instrument may be used to detect thixotropy or shear hardening. A.

532.14

1501. The densities of liquid tritium, 20·6 to 29°K. E. R. Grilly. *J. Amer. Chem. Soc.*, **73**, 5307–8 (*Nov.*, 1951).

Most of a 70 cm³ (S.T.P.) sample of tritium (containing $2{\cdot}0\%$ HT) was liquefied in a Pyrex bulb of 58 mm³ capacity between two fixed marks. The amount of gas used for this filling gave the difference between liquid and gas density. The results were corrected for gas density and for the presence of HT. A.

532.5 : 536.255

1502. Detection of small fluid flows by means of P^{32}. F. T. Rogers, Jr, and L. E. Schilberg. *Nucleonics*, **9**, 47–51 (*Oct.*, 1951).

The onset of convective flow after heat is applied to a system consisting of a liquid in a porous medium (sand in this case), was detected by inoculating quantities of $H_3P^{32}O_4$ into the system and noting sudden changes in counting rate in a β-counter immersed in the sand. The method was compared with the visual method of observing a dye sample near the transparent walls of the containing vessels and a thermal method based on observations with thermocouples immersed in the system. In general the radioisotope method gave the earliest indication of convective flow. L. R. SHEPHERD

532.516

1503. Viscous buttressing. F. Charron. *C.R. Acad. Sci.* [*Paris*] **233**, 1170–2 (*Nov.* 12, 1951) *In French.*

A comparison between the forces of viscosity under instantaneous pressure and those of friction. T. C. TOYE

532.516

1504. Studies in Newtonian flow. II. The dependence of the viscosity of liquids on free-space. A. K. Doolittle. *J. Appl. Phys.*, **22**, 1471–5 (*Dec.*, 1951).

For Pt I, see Abstr. 7587 (1951). It is shown that the viscosity of the liquid normal paraffins

can be accurately defined as a simple function of relative free-space except for values in the neighbourhood of the freezing points of each compound. A novel method of extrapolating the specific volumes of this family of compounds to absolute zero is described which permits the calculation of reliable values of the relative free-space from density data. An expression of the same form as the author's function, but in which temperature rather than free-space is the primary variable (the so-called Andrade equation), fails to reproduce the viscosity of *n*-heptadecane over the same range of temperatures within the limits of the known accuracy of the measurements. A.

532.517

1505. A brief note on the laminar sub-layer of the turbulent boundary layer. B. HUDIMOTO. *Mem. Fac. Engng Kyoto Univ.*, **13**, 174–9 (*Oct.*, 1951).

532.517

1506. Motion of fluids through porous media. P. L. ROMITA. *Ric. Sci.*, **21**, 1978–98 (*Nov.*, 1951) *In Italian.*

To determine the limits of validity of the Darcy law, the author takes into consideration and compares the results of the researches on filtration carried out during the last 20 years, that have reached and passed these limits covering at least part of the transition range between linear and quadratic resistance, particular attention being paid to the beds of loose material. The experimental results are reduced to a common basis by taking into account the porosity of the bed, with a method which proves to be particularly effective and leads to the definition of a generalized Reynolds number for the filtration processes. The limit of validity of the Darcy law is established in terms of this Reynolds number and an expression for the resistance law in the transition range, for beds of spherical or rounded elements, is suggested, on the basis of the examined results and with the support of some results obtained by the author. A.

532.517

1507. On the existence of plane periodic irrotational motions of a heavy incompressible liquid. R. GERBER. *C.R. Acad. Sci.* [*Paris*] **233**, 1261–3 (*Nov.* 19, 1951) *In French.*

The existence is proved, under certain conditions, of types of flow which are periodic in a horizontal direction, corresponding to steady flow of a perfect-fluid sea over a corrugated bed. J. G. OLDROYD

532.517.4

1508. Contribution to the study of incompressible fluids in turbulent motion. J. VAN ISACKER. *Inst. Roy. Met. Belge Mem., No.* 43, 44 *pp.* (1951) *In French.*

Theories of turbulent flow of incompressible fluids, developed (1) from the macroscopic point of view, as, e.g. in the work of Prandtl, Von Kármán, Taylor and others, in which the effects of turbulence upon the distribution of mean velocities and upon flow are discussed without reference to the mechanism of turbulence, and (2) from the microscopic and statistical points of view, as in the work of Taylor, Von Kármán, Kolmogoroff, Heisenberg and others, in which the principal characteristics of turbulent flow are developed in terms of the correlation of velocities and energy spectra, are discussed. The microscopic theory does not permit the calculation of apparent viscosity, since the hypothesis of homogeneity and isotropy necessarily implies the absence of tensions. A synthesis of the two points of view is attempted by introducing the notions of length of mixture and mean motion in Heisenberg's theory. An expression for the energy of turbulence equivalent to that of Prandtl for large Reynolds numbers is so obtained. All theories involve an indeterminate parameter in the form of l, the mixture length. Van Kármán's discussion of this matter does not respect the elementary rules of variance, more especially in respect to the fact that $l = \kappa(\partial u/\partial z)^2/\partial^2 u/\partial z^2$ is not an invariant. A general equation for l is derived, based in part upon arbitrary assumptions, but justified by experimental results. The roughness of conduits is treated in some detail, reference being made to the experimental work of Nikuradze and empirical results obtained by Einstein. J. S. G. THOMAS

532.517.4

1509. On the foundations of certain theories of turbulence. M. Z. v. KRZYWOBLOCKI. *J. Franklin Inst.*, **252**, 409–12 (*Nov.*, 1951).

The author shows that modern theories of turbulence based on hydrodynamics equations seem to offer only a limited number of possible solutions. A.

532.527

1510. On Heisenberg's spectrum of turbulence. N. R. SEN. *Bull. Calcutta Math. Soc.*, **43**, 1–7 (*March*, 1951).

Taylor showed that the important properties of isotropic turbulence can be studied by means of a spectrum function, $F(\kappa, t)$ representing the distribution of turbulent energy among the wave numbers corresponding to fluctuations of velocity in turbulence. It has not, so far, been possible to determine the spectrum function, F, from the equations of mechanics; empirical forms are being studied. Heisenberg has suggested $F(\kappa, t) \sim (1/\sqrt{t})f(\kappa\sqrt{t})$, which is such that an integral equation for f is easily obtainable. This suggested form for F makes $F(\kappa) \sim \kappa$ for large eddies, and $\sim \kappa^{-5/3}$ for an infinite value of Reynolds number; the latter corresponds with the well-known Kolmogoroff spectrum. Lin and Batchelor, however, have found, from different considerations, that $F(\kappa) \sim \kappa^4$ for small κ. Assuming $F(\kappa, t) = (1/\kappa^2)(1/\kappa_0^3 t_0^2)(s^3/\tau^2) f(s, \kappa/\kappa_0)$ where $s = s(\tau)$, $\tau = t/t_0$ and κ_0, t_0 are constants, a general type of homologous solution of the general equation of decay is derived. For the case $R \gg 1$ this yields $F(x, t) = (1/\kappa^2)(1/\kappa_0^3 t_0^2)(t_0/t)^{2-3c} f[(\kappa/\kappa_0), (t/t_0)^c]$ where $c = \tau.s\tau/s$ and $s = \alpha\tau^c$. When energy dissipation by friction is of most importance $F(\kappa, t) = F(\kappa, t_0)$ exp. $[-2\nu\kappa^2(t - t_0)]$. J. S. G. THOMAS

532.542

1511. Fluid flow in ducts with a uniformly distributed leakage. J. F. HOLDSWORTH, F. W. PRITCHARD AND W. H. WALTON. *Brit. J. Appl. Phys.*, **2**, 320–4 (*Nov.*, 1951).

An analysis of the problem is given for any power law relationship between flow rate and pressure

gradient and between leakage rate and excess pressure in a duct. The results relate the pressure drop, inlet flow rate and outlet flow rate for a leaking duct to the pressure drop and flow rate in a similar leakless duct. It is shown that these quantities can be conveniently obtained using a nomogram involving a resistance constant and a leakage constant for the duct. Assumptions involved are discussed and a description is given of a model experiment which confirms the results of the theoretical treatment. A.

532.570 : 539.16

1512. An induction flowmeter design suitable for radioactive liquids. W. G. JAMES. *Rev. Sci. Instrum.*, **22**, 989–1002 (*Dec.*, 1951).

A brief discussion of the principle of the induction flowmeter is presented, and also a discussion of the considerations necessary for applying the induction flowmeter to the measurement of radioactive liquid flow rates of the order of 50 millilitres per minute. These considerations have been applied to the design of a zero-to-fifty millilitre-per-minute flowmeter. Linearity of response of $\pm 1\%$ of full scale has been obtained in this instrument; stability from hour to hour is also $\pm 1\%$ of full scale. Liquids having conductivity at least as great as that of tap water can be measured without change of calibration. A.

532.570 : 578

1513. An optically recording tambour flowmeter and a compensator for large volume blood flow. G. A. BRECHER AND E. R. RITTER. *Rev. Sci. Instrum.*, **22**, 1018–19 (*Dec.*, 1951).

An optically recording flowmeter for measuring rate and volume of blood flow in experimental animals by the phlebotomy method is described. The advantages of the flowmeter are its great accuracy, sensitivity, linear calibration, minimal time lag, and above all its simplicity when used with optically recording manometers. In conjunction with a simple "compensating switch" for the outflowing blood, it permits measurement of very large volume flows without reduction of the arterial blood pressure. A.

CAPILLARITY 532.6

532.6 : 541.183

1514. The spherical interface. I. Thermodynamics. F. P. BUFF. *J. Chem. Phys.*, **19**, 1591–5 (*Dec.*, 1951).

An extension of the Gibbs thermodynamic theory of spherical interfaces leads to generalized forms for the Kelvin relation and the Gibbs adsorption equation. Quantities of physical interest are calculated in terms of the particular dividing surface making the superficial density of matter vanish, frequently more convenient than the surface of tension. An expression is proposed for the work required to form a droplet which is not in equilibrium with the surrounding vapour. A.

532.6.08

1515. On the measurement of kinetic surface tension. E. FERRONI AND G. ROVAL. *Atti Accad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **11**, 202–5 (*Sept.–Oct.*, 1951) *In Italian.*

Previous investigations had shown that the functional relation between the kinetic surface tension, i.e. the surface tension of a moving liquid, and the speed of flow is characterized by a broken curve rising linearly up to a critical value of speed and then becoming horizontal. In the present article the effect of various characteristics of the tensiometer ring—material, diameter of wire, diameter of ring and position of ring—are investigated and a formula is derived allowing of calculating the kinetic surface tension for given values of speed of flow, diameter of ring and dynamic surface tension. Calculated and measured values are in good agreement. R. NEUMANN

532.613.2

1516. The flow of liquid metals on solid metal surfaces and its relation to soldering, brazing, and hot-dip coating. G. L. J. BAILEY AND H. C. WATKINS. *J. Inst. Met.*, **80**, 57–76 (*Oct.*, 1951).

Most of the work was carried out using hydrogen as flux, but a few experiments with liquid fluxes are also described. It is found that the contact angle between solid and liquid surfaces of the metals examined is not, in general, zero. Its true value in given circumstances is obscured by the effects of roughness of the solid surface, which cannot be allowed for. Roughness effects could also account for the fact that the contact angle against a surface over which liquid has receded is generally lower than that against a surface over which liquid has advanced. The development of the particularly low contact angles which are formed against Cu by Sn–Pb alloys with compositions in the range preferred for practical soldering, appears to be preceded by the formation of an alloy layer in the surface of the Cu over which the liquid metal spreads. The production of particularly low contact angles between Pb and Fe or Cu and between Sn and Cu is described. A.

532.66

1517. The rate of rise of liquids in fine vertical capillaries. J. R. LIGENZA AND R. B. BERNSTEIN. *J. Amer. Chem. Soc.*, **73**, 4636–8 (*Oct.*, 1951).

The rates of ascent of several liquids in two vertical fine capillary tubes have been measured. By the use of tubes of radii 0·002 to 0·005 cm, in which the rate of rise is quite slow for most liquids, precise data are readily obtained. The small velocity makes possible a simplification of the differential equation of motion, resulting in a simple solution suitable for direct comparison with experiment. The data could be represented by this expression over the entire ascent. For the initial portion of the rise in short, fine vertically mounted capillaries, the equation reduces to the approximation $h^2 = R\gamma t/4\eta$, suggesting a rapid and simple method for the estimation of the viscosity of micro quantities of liquids. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

1518. On the theory of holes in liquids. Calculation of the volume variation at fusion. G. SUTRA. *C.R. Acad. Sci.* [*Paris*] **233**, 1186–7 (*Nov.* 12, 1951) *In French.*

Continuation of Abstr. 807 (1952).

532.7

1519. Lattice theories of the liquid state. J. S. Rowlinson and C. F. Curtiss. *J. Chem. Phys.*, **19**, 1519–30 (*Dec.*, 1951).

The assumptions underlying the lattice theory of liquids of Lennard-Jones and Devonshire are examined. Four modifications of this theory have been proposed which avoid some of these assumptions. These modifications are (*a*) by Cernuschi and Eyring, (*b*) by Ono, (*c*) by Peck and Hill, and (*d*) one suggested in this paper. It is shown that they may all be deduced as special cases of one mathematical treatment. They are intuitively more attractive than the original theory and avoid any mention of the so-called "communal entropy." They give reasonable values of the second varial coefficient. None of them, though, shows much improvement over the original theory in calculating the critical constants and vapour pressure curves. A.

532.72

1520. Investigations on thermodiffusion in the liquid phase. G. Thomaes. *Physica*, **17**, 885–98 (*Oct.*, 1951) *In French.*

See Abstr. 120, 3385 (1951). The author has studied the Soret effect by an optical method which is described. The experiments have been carried out with the following organic solutions: cyclohexane/carbon tetrachloride, benzene/chlorobenzene, carbon tetrachloride/chlorobenzene, carbon tetrachloride/bromobenzene, benzene/cyclohexane, tetrachlorethane/tetrabromethane, benzene/methanol. The Soret coefficients are given as a function of the mole fraction for the systems presenting a sufficient separation. The sign reversal of thermodiffusion coefficient (D') was recorded in the case of the benzene/methyl alcohol systems for an alcoholic mole fraction of 0·16. The phenomenological theory is discussed in relation to the boundary singularities which, according to Tanner, appear during the initial stages of the phenomenon. It is shown that De Groot's approximation for the determination of the isothermal coefficient of diffusion cannot lead to correct results. The results, obtained by Soret, and thermogravitational methods show good agreement. Both corroborate the kinetic scheme developed by I. Prigogine [Abstr. 120 (1951)]. A.

532.73 : 534.22.096

1521. Ultrasonic propagation in binary liquid systems near their critical solution temperature. A. G. Chynoweth and W. G. Schneider. *J. Chem. Phys.*, **19**, 1566–70 (*Dec.*, 1951).

An investigation has been made on the propagation of ultrasonic waves (at 600 kc/s) through the critical solution temperature of two binary liquid systems; (1) aniline and *n*-hexane, and (2) triethylamine and water. Results are given for the variation of the velocity with temperature. The behaviour of the sound attenuation through the critical point is also shown. In both systems studied the attenuation exhibited a marked maximum at the critical solution temperature. A possible explanation of this effect is that the sound wave gives rise to configurational relaxation processes of greatly increased magnitude on account of the molecular clustering in the liquid system near its critical solution temperature. A.

532.74 : 537.531 : 535.43

1522. Fourier analysis of the X-ray scattering from soap solutions. G. W. Brady. *J. Chem. Phys.*, **19**, 1547–51 (*Dec.*, 1951).

A Fourier analysis of the X-ray diffraction of sodium dodecyl sulphate has been made on the basis that the micelles formed by aggregation of the long chain molecules are spherical. The radial distribution of the micelles has been determined at two concentrations; the distribution functions show definite peaks indicating a preferred distance for neighbouring micelles. It is concluded that the spherical micelle is compatible with the X-ray evidence. The deficiencies of the lamellar micelle are discussed. A.

532.77

1523. Angular points in the properties of liquids. G. Antonoff, A. Urmanczy and A. Yakimac. *C.R. Acad. Sci.* [*Paris*] **233**, 1450–2 (*Dec.* 3, 1951) *In French.*

If the cube root of the difference between the density of a liquid and that of its vapour is plotted against temperature, angular points are found whenever X (the association factor) is a power of 2. T. C. TOYE

532.77 : 534.39

1524. On the effect of transverse ultrasonic waves in solutions of high polymers. R. Cerf. *C.R. Acad. Sci.* [*Paris*] **233**, 1099–1101 (*Nov.* 5, 1951) *In French.*

An application of a theory developed earlier [*J. Chim. Phys.*, **48**, 59, 85 (1951)] using an elastic sphere as a molecular model. The formulae derived for the specific viscosity and relaxation time of the solution agree qualitatively with experiment, and explain in particular the observed decrease at high frequencies in the elasticity modulus of dilute solutions with increase in temperature. H. H. GREENWOOD

MECHANICS OF GASES 533

533.15

1525. Thermal diffusion in H_2—D_2 and H_2—He mixtures at low temperatures. A. de Troyer, A. van Itterbeek and A. O. Rietveld. *Physica*, **17**, 938–42 (*Nov.–Dec.*, 1951).

See Abstr. 1654 (1951). Measurements on thermal diffusion in the binary gas mixtures H_2–D_2 and H_2–He were carried out between room temperature at one end and liquid oxygen or liquid hydrogen temperatures at the other end. For both mixtures a change of the thermal diffusion coefficient at the lowest temperatures was found and also a change of the sign of this coefficient. A.

533.15

1526. Diffusion in CO_2 up to 150 atmospheres pressure. W. L. Robb and H. G. Drickamer. *J. Chem. Phys.*, **19**, 1504–8 (*Dec.*, 1951).

Diffusion coefficients have been obtained for the system CO_2–$C^{14}O_2$ up to 150 atm. pressure and from 0°–45°C. The coefficients are consistent with theory up to a density of 0·067 gm/cm^3. In the range from 0·067–0·70 g/cm^3 the coefficients are higher than predicted by theory. This may be attributed to a reduced collision diameter due to orientation of the

non-spherical molecules. At higher densities the experimental coefficients are lower than the theoretical ones. This is expected as the theory breaks down at these high densities. At densities above 0·65 g/cm³ no measurable temperature coefficient of D was obtained. This may be explained by increased orientation at lower temperatures and in the liquid state. A.

533.15 : 518.1 : 519.2

1527. Monte-Carlo method for solving diffusion problems. G. W. KING. *Industr. Engng Chem.*, **43**, 2475–8 (*Nov.*, 1951).

The diffusion equation is an analytical idealization of a physical process, and except in simple cases no analytical solution is available. Conventional calculations, therefore, adopt various approximation devices. The Monte Carlo method utilizes the great calculating speed of modern machines to solve diffusion problems without recourse to analytical forms, e.g. by actually applying a random series of increments (+ or −) to an assemblage of quantities, in analogy to Brownian movements, and evaluating the resulting distribution. The simplicity with which boundary values, and other *a priori* conditions, can be introduced, and the ease of generalization to 3 dimensions, is pointed out.

533.16 : 536.48

1528. The viscosity of gaseous He^3 at low temperatures. J. DE BOER AND E. G. D. COHEN. *Physica*, **17**, 993–1000 (*Nov.–Dec.*, 1951).

The viscosity of gaseous He^3 has been calculated using the general quantum mechanical expressions for the coefficient of viscosity. The calculation is based on the intermolecular potential field, used previously for the calculation of the equation of state of He^3 in the gas state [Abstr. 8503 (1950)] and for the equation of state and transport properties of gaseous He^4. The theoretical results, which are limited to temperatures below 5°K, show that the viscosity of He^3 is about two times larger than when calculated from the viscosity of He^4, taking into account only the difference in mass. There is also a marked influence of the nuclear spin and the statistics at these low temperatures. A.

533.17 : 533.5

1529. The flow characteristics of capillary leaks. N. OCHERT AND W. STECKELMACHER. *Brit. J. Appl. Phys.*, **2**, 332–3 (*Nov.*, 1951).

An error in the formula given by Guthrie and Wakerling (*Vacuum equipment and techniques*) is pointed out.

533.275 : 551.508.7

1530. Methods of measuring humidity and testing hygrometers. A. WEXLER AND W. G. BROMBACHER. *Circ. Nat. Bur. Stand., No.* 512, 17 *pp.* (1951).

This paper is a review of methods for the measurement of the water-vapour content of air and other gases and for the production and control of atmospheres of known humidity for hygrometer testing and calibration and for general research. Among the hygrometric techniques discussed are psychrometry, mechanical hygrometry, dewpoint measurement, electric hygrometry, gravimetric hygrometry, thermal conductivity, index of refraction, pressure and volume measurements and dielectric constant. Descriptions are given of suitable equipment for establishing desired humidities over a wide range of temperature. A list of 157 selected references pertaining to hygrometry is included. A.

533.5

1531. A high-vacuum pumping unit for the laboratory. H. BOERSCH. *Z. Phys.*, **130**, 513–16 (*No.* 4, 1951) *In German.*

The unit consists of the forepump, high-vacuum diffusion pump, valves, water flow safety valve, vacuum gauge and electrical control gear. The gear is mounted on a box trolley. The pumps are fitted with shock absorbers. W. SUMMER

533.5

1532. A simple indication of leaks in high vacuum apparatus. E. VÖLCKER. *Z. Naturforsch.*, **6a**, 512–13 (*Sept.*, 1951) *In German.*

The apparatus is painted with a thin film of dilute fluorescent solution of fluorescein or eosin, which seeps into the cracks and leaks when the apparatus is evacuated. If then the cleaned apparatus is illuminated with u.v. light the leaks are indicated by the fluorescent places. S. WEINTROUB

533.5

1533. Vacuum gauge using α-rays. C. GIMENEZ AND J. LABEYRIE. *J. Phys. Radium*, **12**, 64 A–65 A (*Oct.*, 1951) *In French.*

Similar in principle to the "Alphatron" [Abstr. 2497 (1946)]. The radiation source is Po on Ni and the pressure range 10^{-1} to 10^{2} mm Hg. The gauge is particularly useful for corrosive gases and for the estimation of the proportion of a gas in a mixture of two gases. The saturation current varies linearly with the pressure, and results for various gases and for the mixtures Xe–He, A–Ne are shown graphically. S. WEINTROUB

533.5

1534. [Vacuum] valve with parallel channels and pneumatic control for thermal evaporation apparatus. P. PRUGNE. *J. Phys. Radium*, **12**, 66 A (*Oct.*, 1951) *In French.*

A cut-off valve for use between the diffusion pump and bell-jar. A conical hole is cut in the side of the 6 cm diameter connection pipe and a rubber sheet held in place by a cover plate is fitted over the hole. The space between the rubber and the cover can be connected with either the backing pump or compressed air. When distended under pressure the rubber effectively seals both sides of the pipe. S. WEINTROUB

533.5

1535. Fundamentals of vacuum dessication. L. DUNOYER. *Vide*, **6**, 1025–40 (*July–Sept.*); 1077–90 (*Nov.*, 1951) *In French.*

A method and theory of dessicating products in a highly diluted state is given, referring particularly to products that must not be treated at elevated temperatures. The parameters influencing the total evaporation time are: latent heat of evaporation, vapour tension, the heat conductivity and wall thickness of the vessel containing the liquid, the surface of

contact between the liquid and its vessel, the initial temperature of the liquid (varying between + 35°C to − 80°C), and the ambient temperature of the vessel. This latter temperature is kept constant by immersing the vessel in a water bath (0°C to 35°C). The existence of a temperature limit has been established. This limit operates from the moment the first small quantity of water is evaporated. From then evaporation takes place under conditions of constant temperature and at constant rate. It has been shown that the temperature of the water bath and the characteristics of the connecting pipes and condenser can so be rated as to give optimum results. The evaporation of ice is also discussed. Approximate formulae are developed for practical calculation to replace the complex theoretical formulation. W. SUMMER

533.5 : 531.788.7

1536. Notes on the ionization gauge. L. RIDDIFORD. *J. Sci. Instrum.*, **28**, 375–9 (*Dec.*, 1951).

The notes are based on 2 years' experience of the gauges used with the Birmingham University synchrotron; hot filament ionization gauges were found to be reliable down to the lowest pressures ($< 10^{-6}$ mm of Hg). The sensitivity of the hot-filament gauge is in good agreement with theoretical values calculated on the basis of a physical picture of a stream of electrons passing to and fro through the ionizing space. The calibration curve is not exactly linear, the sensitivity decreasing as the pressure increases from 10^{-4} to 10^{-3} mm of Hg. The tungsten filament in such a gauge "pumps" oxygen at a rate which is in agreement with earlier work of Langmuir. The remanent molecules which determine the ultimate pressures of diffusion pumps are strongly adsorbed by the gauge, which behaves as a pump of constant speed. An account of the nature of this phenomenon is given. A.

533.52

1537. An all-glass, two-stage, mercury diffusion pump of simple construction. A. K. DUTTA. Letter in *J. Sci. Industr. Res.*, **10B**, 261 (*Oct.*, 1951).

533.56

1538. Investigations into the ultimate pressures of diffusion pumps designed to purify their working fluids. D. LATHAM, B. D. POWER AND N. T. M. DENNIS. *Vacuum*, **1**, 97–114 (*April*, 1951).

A diffusion pump which powerfully purifies its fluid from contaminants and decomposition products can produce very low pressures as quickly with a fluid of commercial quality as it can with a specially prepared fluid. This is demonstrated by comparative tests on pumps designed to purify continuously their working fluids with varying efficiency, and operated with proprietory pumping fluids and with commercial plasticizers. Fluid decomposition may contribute both permanent gas and vapour components to the ultimate pressure so that in certain cases only a moderate improvement in "ultimate" can be obtained by the use of a refrigerated trap. In a pump designed to keep the concentration of decomposition products in its fluid at a very low level, the rate of evolution of gaseous products is reduced, probably because intermediate products of fluid breakdown tend to be removed before they finally decompose into gases. In addition to the much lower total pressure which may be obtained by such a pump, the application of a refrigerated trap may be much more effective. These advantages can be obtained in a pump of robust and simple design without prejudice to other performance characteristics. A.

533.56

1539. Refrigeration of oil diffusion pump baffles. R. S. BARTON AND A. H. TURNBULL. Letter in *Vacuum*, **1**, 117–18 (*April*, 1951).

533.6.011

1540. On the anomalous Magnus effect. I. TANI. Letter in *J. Appl. Phys.*, **22**, 1506–7 (*Dec.*, 1951).

Attention is directed to results obtained by Davies relating to the forces on smooth and rough golf balls spinning in a wind [see Abstr. 780 (1950)]. The author had previously found similar results, but had not observed a negative force at low rotational speeds; the existence of this negative force had, however, been reported by 4 experimenters. Davies, in explanation of the negative force, suggested that the effective Reynolds number is higher on the side rotating against the wind than on that rotating with the wind, but gave no reason for this difference. The author amplifies and clarifies Davies's explanation by considering that a fluid particle describes a stable, flattened, closed circuit on the side of the ball rotating against the wind. Stability of the circuit is ensured only if the rotational speed is low, the surface of the ball is smooth and stream turbulence small.

J. S. G. THOMAS

533.6.011 : 532.517.4

1541. The fluctuations of density in isotropic turbulence. S. CHANDRASEKHAR. *Proc. Roy. Soc. A*, **210**, 18–25 (*Dec.* 7, 1951).

In this paper the fluctuations of density in a compressible fluid under conditions of homogeneous isotropic turbulence are considered. It is shown how from the equation of continuity alone, an invariant can be derived. Thus, if $\omega(r, t) = \overline{\delta\rho\delta\rho'}$ denotes the correlation between the instantaneous fluctuations of the density from the mean, at two points separated by a distance r, then $\int_0^\infty r^2\omega(r, t)dr = \text{constant}$. The meaning of this invariant is that the largest scales of the fluctuations of density are determined by the initial conditions of the problem and represent permanent features of the system. An equation of motion for $\omega(r, t)$ is also derived which relates the fluctuations in density with the fluctuations in velocity; if, as an approximation, we substitute in this equation of motion the expression for the fundamental correlation tensor $\overline{u_i u'_j}$ which is valid for an incompressible fluid, we obtain a simple equation connecting ω and the defining scalar, Q, of $\overline{u_i u'_j}$. When $\overline{u^2} \ll c^2$ (where c denotes the velocity of sound) the equation for ω is of the same form as that governing the propagation of spherical sound waves except that the velocity of propagation is not c but $\sqrt{2}c$. More generally, it is found that when the term in Q is included, the equation for ω still admits periodic solutions of the form of spherical waves; but they are distorted for small values of r and are propagated with a velocity $(2c^2 + \frac{2}{3}\overline{u^2})^{\frac{1}{2}}$. Also, under the same

conditions we can picture $\omega(r, t)$ as a superposition of the fundamental periodic solutions. A.

533.6.011.3

1542. One-dimensional flows of an imperfect diatomic gas. A. J. Eggers, Jr. *Tech. Rep. Nat. Adv. Comm. Aeronaut., No.* 959, 11 *pp.* (1950).

Berthelot's equation of states is used to describe the equilibrium states of the gas. Only the temperature-dependent part of the specific heats needs to be considered. For aerodynamic applications the number of translational and rotational degrees of freedom is constant, and only the temperature variation of the vibrational heat capacity need be considered. This is done through the Einstein function involving the characteristic temperature θ. One-dimensional isentropic flow equations and shock relations are then obtained. MATHEMATICAL REVIEWS

533.6.011.3

1543. Approximate solutions of compressible flows past bodies of revolution by variational method. C.-T. Wang and S. de los Santos. *J. Appl. Mech.*, **18,** 260–6 (*Sept.*, 1951).

Using the direct method of Rayleigh–Ritz in the calculus of variations, the problem of steady irrotational compressible flow past a body of revolution of arbitrary shape is formulated. In order to compare with the analytical solutions obtained by other investigators, two numerical examples have been carried out, namely, compressible flows past a sphere, and an ellipsoid of revolution. The results are found to be in excellent agreement with those computed by other approximate methods. A.

533.6.011.311

1544. The boundary layer in three dimensional flow. II. The flow near a stagnation point. L. Howarth. *Phil. Mag.*, **42,** 1433–40 (*Dec.*, 1951).

For Pt I, see Abstr. 3369 (1951). The equations of boundary layer flow in the vicinity of a stagnation point on a general (three dimensional) surface are discussed and shown to be reducible to a pair of simultaneous ordinary third-order differential equations containing a single parameter c which is determined by the mainstream flow. The variation of c can be effectively limited to the range from 0 (corresponding to two dimensional flow) to 1 (corresponding to the axial flow past a body of revolution), and solutions have been computed for the cases $c = 0{\cdot}25$, $0{\cdot}50$, $0{\cdot}75$ and are tabulated below. A series expansion useful for small c is also given. A.

533.6.011.4

1545. Singularities characterizing the transonic régime, and the problem of the profile of resistance minima at supersonic velocities. D. Riabouchinsky. *C.R. Acad. Sci.* [*Paris*] **233,** 1330–3 (*Nov.* 26, 1951) *In French.*

The author's theory of the resistance of compressible fluid at ballistic velocities [Abstr. 5170 (1951); *J. R. Aero Soc.*, **39,** 399 (1935)] is compared with Ackeret's theory [*Helv. Phys. Acta*, **1,** 301–22 (*No.* 5, 1928)] which leads to the conclusion that a moving body experiences an infinite resistance in the sonic domain of velocities. It is shown that the profile of resistance minima is limited by two circular arcs, a result which agrees with experimental results obtained by Theodorsen and Rigier (1944).

J. S. G. THOMAS

533.6.011.5

1546. Transonic flow past finite wedges. A. G. Mackie and D. C. Pack. *Proc. Camb. Phil. Soc.*, **48,** 178–88 (*Pt I*, 1951).

The solution for the flow of an incompressible fluid is generalized by the hodograph method. In the flow thus obtained the axis of symmetry and a sloping edge of the wedge are again part of one streamline. It becomes possible to describe the flow of an ideal gas past a finite wedge if the hypothesis is made that the first singularity on this streamline along the sloping edge, corresponds to the shoulder of the wedge. For a given wedge, with gradually increasing velocity at infinity upstream, the singularity appears at first at subsonic velocity. Beyond a certain critical velocity at infinity the singularity is always associated with the speed of sound. A.

MOLECULAR THEORY OF GASES 533.7

533.75

1547. The second virial coefficient of benzene. A. E. Korvezee. *Rec. Trav. Chim. Pays-Bas*, **70,** 697–710 (*Sept.–Oct.*, 1951).

A one-parameter family of curves for the second virial coefficient of benzene as a function of temperature is computed from published precision thermal measurements. Theoretical formulae for $B(T)$ are compared with this experimental temperature relation. A.

VIBRATIONS . ACOUSTICS 534

534.014.2

1548. Forced oscillations with nonlinear restoring force. C. Hayashi. *Mem. Fac. Engng Kyoto Univ.*, **13,** 180–97 (*Oct.*, 1951).

Forced oscillations with nonlinear restoring force are studied in transient states as well as in steady states. The differential equations which govern the oscillations are under some restrictions transformed to the form: $dy/dx = Y(x,y)/X(x,y)$, and the integral curves of this equation are studied according to Poincaré and Bendixson with the basic idea that the singularities of the above equation are correlated with the periodic steady states of oscillation and the integral curves with transient states. A.

534.014.5

1549. Studies in nonlinear vibration theory. S. Fifer. *J. Appl. Phys.*, **22,** 1421–8 (*Dec.*, 1951).

The author determines the stability of periodic solutions of (1) the general forced Duffing equation without damping, $\ddot{x} + x + \varepsilon f(x) = \varepsilon E \cos\omega t$, $f(x)$ a polynomial, $\varepsilon \ll 1$; (2) the forced Duffing equation with damping, $\ddot{x} + \varepsilon r\dot{x} + \alpha x + \varepsilon x^3 = \varepsilon E \cos(\omega t + \phi)$,

$\varepsilon \ll 1$; and (3) the general forced Van der Pol equation, $\ddot{x} - \varepsilon f(\dot{x}) + x = \varepsilon E \cos(\omega t + \phi)$, $f(\dot{x})$ an odd polynomial, $\varepsilon \ll 1$, by seeking conditions necessary to insure periodic or almost-periodic solutions of the corresponding variational equation. The former are obtained rigorously by means of an existence proof and the latter formally by perturbation series. A vertical tangent theorem is derived which states that the locus of the points of contact of the vertical tangents to the response curves is a stability boundary, since it coincides, in the first approximation, with the locus of periodic solutions of the variational equation. These techniques are illustrated by considering the forced vibrations of a triode oscillator with a fifth-order tube characteristic, this being a particular case of (3), where $f(\dot{x}) = \dot{x} - \frac{1}{3}\dot{x}^3 + \lambda\dot{x}^5$. A.

534.121.1

1550. Transverse vibrations of a free circular plate carrying concentrated mass. R. E. ROBERSON. *J. Appl. Mech.*, **18**, 280–2 (*Sept.*, 1951).

The plate under consideration carries a concentrated mass at its centre, which is struck impulsively in a direction perpendicular to the undisturbed plate face. Only circularly symmetric vibrations are considered. The solution is carried out by the use of the Laplace transform method, treating the concentrated mass as a plate-density impulse. The first four natural frequencies are displayed as functions of mass ratio, and the first mode shape is displayed for three mass ratios. The natural frequencies, particularly the higher, are shown to be very sensitive to changes in mass ratio at small values of the concentrated mass. A.

534.134

1551. A laboratory experiment with coupled linear oscillators. F. MILLER, JR. *Amer. J. Phys.*, **20**, 23–5 (*Jan.*, 1952).

Two rolling masses and three helical springs are arranged collinearly in a horizontal plane. Longitudinal vibrations of the system are excited manually and the two normal modes studied. Calculated and observed frequencies can be compared in detail, since the coupling constant is directly measured. Agreement is obtained to within a few percent. A.

534.15 : 537.523.3

Positive sphere corona: oscillation measurements. *See Abstr.* 1816

534.2 : 530.162

1552. The calculation of the thermal noise in air. L. L. BOYARSKY. Letter in *J. Acoust. Soc. Amer.*, **23**, 716 (*Nov.*, 1951).

The basis of the calculation is to consider a cavity containing gas molecules as an acoustic blackbody in which standing waves of sound are set up due to the Brownian movement of the molecules of air.

G. F. HODSMAN

534.21

1553. The propagation of sound waves through a medium with very small random variations in refractive index. T. H. ELLISON. *J. Atmos. Terr. Phys.*, **2**, 14–21 (*No.* 1, 1951).

Mathematical techniques, developed for the theory of turbulence, are applied to the study of the propagation of waves in a medium in which the refractive index varies slightly with position in a random manner. Both a diffraction and a ray theory are used to relate the statistical properties of the wave to those of the refractive index field, and the conditions for the validity of the ray theory are exposed. A particular result is, that, for a wave travelling in a statistically homogeneous medium where the scale of the variations in refractive index is suitably large compared with the wavelength but small compared with the path length, the variations in intensity produced by the medium are proportional to the cube of the path length for short paths, but directly proportional to it for long paths. A.

534.21

1554. Exact and approximate equations for wave propagation in acoustic horns. A. F. STEVENSON. *J. Appl. Phys.*, **22**, 1461–3 (*Dec.*, 1951).

Exact equations are given for the propagation of acoustic waves in horns of arbitrary shape. These equations are similar to, though simpler than, the equations previously found for electromagnetic horns, and can be regarded as giving rise to an infinite number of coupled modes of propagation. If the coupling is neglected, the equation for the fundamental mode is the familiar one, but the theory also furnishes equations for the higher modes. The error involved in neglecting coupling is discussed. A.

534.21 : 550.34

1555. Elastic waves through a packing of spheres. F. GASSMANN. *Geophysics*, **16**, 673–85 (*Oct.*, 1951). Also in *Mitt. Inst. Geophys., E.T.H. Zürich, No.* 21 (1952).

The elasticity of a hexagonal close packing of equal spheres is treated on a previously developed theory of porous solids [Abstr. 9743 (1951)]. The packing is anisotropic and because of the weight of the spheres, also inhomogeneous. The velocities of propagation of elastic waves have been calculated for evacuated interspaces and for interspaces filled with a liquid or gas. In the case of evacuated or air-filled interspaces, the wave rays and travel times have been computed. The packing which has been treated may be of use as a model for a dry or wet loose material such as gravel or sand. Though the model is very simplified, the results obtained show some typical effects such as anisotropy, inhomogeneity, and a 90° angle of emergence. A.

534.22

1556. Mersenne and Gassendi. An early chapter in the history of sound. J. M. A. LENIHAN. *Acustica*, **1**, 96–9 (*No.* 2, 1951).

It is suggested that the first measurements of the velocity of sound were made by Mersenne (1588–1648). A.

534.22 : 534.321.9

1557. Ultrasonic velocity in supercooled liquids. S. PETRALIA AND M. CEVOLANI. *Ric. Sci.*, **21**, 1623–5 (*Sept.*, 1951) *In Italian.*

Describes measurements in normal and supercooled phenyl salicylate. No sudden variation of velocity was observed at passage of temperature through melting point; moreover velocity was independent of frequency. Values are finally given

of adiabatic and isothermal compressibility of phenyl salicylate at 44°C. A.

534.22.092

1558. The velocity of sound at reduced pressures. P. W. Smith, Jr. Letter in *J. Acoust. Soc. Amer.*, **23**, 715 (*Nov.*, 1951).

A summary is given of a paper by Abbey and Barlow [see Abstr. 3043 (1949)] which describes measurements on the sound velocity in gases at 1 kc/s at pressures between atmospheric and several mm of Hg. An acoustic feedback method was used from a dynamic speaker at one end of a tube containing the gas to a moveable crystal microphone at the other end. Results are given for air, N_2, CO_2, O_2, and CH_4. G. F. Hodsman

534.22.092

1559. Ultrasonic propagation in liquids under high pressures: velocity measurements on water. G. Holton. *J. Appl. Phys.*, **22**, 1407–13 (*Dec.*, 1951).

The electrical apparatus makes use of a presentation unit which synchronizes the sequence of operations by internally generated trigger signals at low repetition rates. Three- to five-μsec pulses at controllable amplitude and approximately 15 Mc/s carrier frequency are imposed on an X-cut quartz crystal which has been placed inside a pressure-supporting vessel containing the test sample. The resulting ultrasonic pulses in the liquid are reflected back and forth over a definite path length between the transducer and a mirror. After amplification in a receiver strip the complete echo-pattern becomes available for visual comparison on the presentation screen. The timed relative delay (and the measurable amplitude differences) between successive pulses furnish data for velocity (and attenuation) measurements when certain corrections are attended to. Representative data are given for the velocity in water (to 0·1 %) as a function of pressure to about 6 000 atm. From the data on water, information is derived on the temperature coefficient of sound velocity and on the ratio of specific heads at increasing pressures. The latter results are compared with those obtained directly from purely static experiments, and the advantages of the ultrasonic measurement technique for the derivation of some of the thermodynamic coefficients are cited. A.

534.22.096

1560. Measurement of the temperature dependence of the velocity of sound for light and heavy water and for water/ethyl alcohol mixtures. P.-P. Heusinger. *Akust. Beih., No.* 1, AB 3–AB 6 (1951) *In German.*

By means of an ultrasonic optical method the absolute velocity of sound is measured at room temperature. Its dependence upon temperature is determined at monotonically increasing temperature using alternate resonance and antiresonance of the standing waves formed between quartz and reflector. This method is superior to other similar methods in that no thermostat is required and it takes only a short time to carry out. A.

534.22.096 : 532.73

Ultrasonic propagation in binary liquid systems near their critical solution temperature. *See Abstr.* 1521

534.222.2

1561. The propagation in a compressible fluid of finite oblique disturbances with energy exchange and change of state. F. W. Ross. *J. Appl. Phys.*, **22**, 1414–21 (*Dec.*, 1951).

Theory is presented for oblique shock waves involving (1) heat exchange, k_1; (2) transfer of part of the compressible fluid, k_2, to an incompressible state, and (3) change in specific heat ratios, k_3. By matching mass flow, momentum, and energy relations across an oblique finite disturbance it is shown that these additional conditions introduce new terms in the solution of the form $k_i u_1/(u_1 - u_2)$. For k_i not zero a minimum shock angle is found which always exceeds the Mach angle by a definite increment. For air-flow at u_1/a of 1·5 with dew point $-20°$F this increment is calculated as 3·1 degrees. For expansion about a corner such flow differs from the Prandtl–Meyer type and in supersonic nozzles, for example, oblique shock waves are predicted which can explain anomalous pressure losses, the presence of extraneous waves, and non-isentropic effects. Hodographs of the velocity solution include a triply infinite set of curves, one, the usual set, introduced by Mach number as parameter and the other two by k_i. The theory includes physically possible normal and oblique flows involving increase of supersonic velocities and subsonic velocities of which oblique flame fronts are indicated as one form. Applied to air condensations in hypersonic flows isentropic disturbances having appreciable angular flow shift and stagnation pressure losses are predicted. A.

534.222.2 : 534.25

1562. On shock-wave phenomena; refraction of shock waves at a gaseous interface. H. Polachek and R. J. Seeger. *Phys. Rev.*, **84**, 922–8 (*Dec.* 1, 1951).

Treats the problem of the refraction of a shock wave at a gaseous interface. The governing equations are formulated and analysed. Continuous families of solutions are obtained numerically for a number of gas combinations at varying angles of incidence on a plane interface between ideal gases (characterized by a certain range of parameters). It is believed that these solutions, which represent a three-wave configuration at the interface with a reflected shock wave or with a reflected rarefaction wave, are physically real inasmuch as they tie in with the two known limiting solutions of an infinitesimal shock at any angle of incidence and of any finite shock at normal incidence. Two of the significant features of the present solutions are: (1) regular refraction (three-wave configuration at the interface) does not occur at glancing incidence and (2) in the region of regular refraction there is no "total reflection" of finite shock waves. A.

534.222.2 : 541.126

1563. Under-water explosion measurements from small charges at short ranges. A. H. Bebb. *Philos. Trans. A*, **244**, 153–75 (*No.* 879, 1951).

Experiments made to obtain pressure-time records of under-water explosion waves are described. The explosives used were cylindrical or spherical, and varied in mass between 2 oz. and 1¼ lb. Measurements were taken at the outside edge of the charge

and at other distances up to 100 charge radii. The pressure-sensitive element employed was a tourmaline gauge, either ½ or ¼ in. in diameter. The shock-wave parameters, at close distances in particular, were found to depend on the shape of the explosive charge. Since the front part of the shock pulse travels faster than the rest, the profile of the pulse spreads as the range increases. The time-constant of the pulse is considerably smaller close to the charge than it is farther away. The results obtained demonstrate the importance of the afterflow energy-flux density relative to the primary shock-wave energy-flux density, especially near to the charge. The results give general confirmation of theories developed in the United States and in the United Kingdom. A.

534.23

1564. Propagation of sound in a duct with constrictions. U. Ingård and D. Pridmore-Brown. *J. Acoust. Soc. Amer.*, **23**, 689–94 (*Nov.*, 1951).

The transmission of sound through a duct periodically loaded with constrictions (iris partitions) is studied. The attenuation as a function of frequency in such ducts both with hard and absorptive side walls is given. In the case of a hard-walled duct the results of the analysis are presented in chart form. It is shown that by proper choice of side wall absorption and iris partitions a broad attenuation band can be obtained. Measured values of the attenuation are found to be in good agreement with the theory. A.

534.23

1565. Propagation of sound in CO_2 at high pressure. G. C. Werth. Letter in *J. Acoust. Soc. Amer.*, **23**, 715–16 (*Nov.*, 1951).

Results are given which indicate a molecular absorption peak at 6·4 atm. at 572 kc/s.

G. F. HODSMAN

534.23

1566. Sound absorption of wood panels for the Royal Festival Hall. P. H. Parkin and H. J. Purkis. *Acustica*, **1**, 81–2 (*No.* 2, 1951).

The sound absorption coefficients of the wood panels to be used for low-frequency absorption in the Royal Festival Hall have been measured by the reverberation chamber technique over the frequency range 50 to 500 c/s. Four types of panels were measured, the variations between the types being different air-spaces and different amounts of cross-bracing. These variations were sufficient to vary the absorption coefficients obtained over the frequency range 50 to 100 c/s; at higher frequencies the absorption coefficients of all types were practically the same. A.

534.23

1567. The absorption of sound and ultrasonics in gases. M. Dubois. *J. Phys. Radium*, **12**, 876–84 (*Nov.*, 1951) *In French.*

A review of the general problem of the attenuation of a plane wave during propagation, due to the properties of the medium and the local modifications produced by the passage of the wave. The factors considered include viscosity, conductivity rise and fall of temperature and the variations in the translational and vibrational energy of the molecules. Theoretical results are compared with those of experiment and an extensive bibliography is given.

G. F. HODSMAN

534.231

1568. Transformer analogs of diaphragms. B. B. Bauer. *J. Acoust. Soc. Amer.*, **23**, 680–3 (*Nov.*, 1951).

The use of the conventional analogue for diaphragms in equivalent circuits often causes serious difficulties. The action of a diaphragm is shown to be analogous to that of a system of ideal transformers, each corresponding to an area of the diaphragm. The ancillary concept of "acoustical ground" analogy is introduced to facilitate synthesis of equivalent electrical circuits. The analysis includes equivalent circuit representations of a piston diaphragm, multiple diaphragms, diaphragms with subdivided sides and articulated diaphragms, etc., together with examples. Simultaneous use of the transformer analogy of diaphragms and the transformer analogy of transducer couplings is treated. A.

534.231

1569. On the relation between the sound fields radiated and diffracted by plane obstacles. F. M. Wiener. *J. Acoust. Soc. Amer.*, **23**, 697–700 (*Nov.*, 1951).

In the past, acoustic diffraction and radiation problems have often been treated separately, although their intimate connection is clear from theory. In the case of plane piston radiators and plane rigid scatterers exposed to a perpendicularly incident plane wave, this connection becomes particularly simple and useful. It is easy to show that the radiated sound field is everywhere the same as the field scattered (diffracted) in the diffraction case, except for a factor of proportionality. It is also shown that the reaction of the medium on the radiator, as expressed by the mechanical radiation impedance, is equal to the force per unit incident pressure exerted on the same obstacle, held rigid as a scatterer, except for a factor of proportionality. By way of illustration, the foregoing principles are applied to the important case of the circular disk. A.

534.231

1570. Field and impedance of an oscillating sphere in a viscoelastic medium with an application to biophysics. H. L. Oestreicher. *J. Acoust. Soc. Amer.*, **23**, 707–14 (*Nov.*, 1951).

With an application to human tissue in view, a theoretical analysis of the behaviour of mechanical vibrations in a medium with elastic, viscous and relaxational properties is made. For this purpose, the equations of wave motion in a viscoelastic medium are discussed in general and solved for two problems, which are significant for the propagation and the transfer of vibrational energy: (1) energy propagation and absorption in plane waves, (2) field and impedance of an oscillating sphere. The results show that the energy is propagated in two kinds of waves, the relative intensities of which change strongly with frequency: transverse waves, owing to the shear elasticity and viscosity, and compression (acoustical) waves, owing to the volume compressibility of the medium. A more detailed treatment is then accomplished for human muscle tissue by inserting the

approximate values of its elastic constants into the general formulae, thus explaining the behaviour in a frequency range from 0 up to several hundred kc/s. A.

534.231.3

1571. On the radiation impedance of a rectangular plate with an infinitely large fixed baffle. Y. NOMURA AND Y. AIDA. *Sci. Rep. Res. Inst. Tôhoku Univ. B*, **1–2**, 337–47 (*March*, 1951).

Formulas for calculating the radiation impedance of the rectangular plate which vibrates normally to the plane of an infinitely large fixed baffle are obtained from the pressure distribution on the plate. The energy distribution at a large distance from the vibrating plate has been calculated by Stenzel and the radiation resistance may be calculated from it but not the reactance component. By numerical calculations it is discussed how the radiation resistance and reactance vary with the shape and size of the vibrating plate. A.

534.232

1572. The radiation of impulses from plane piston membranes in a rigid wall. F. A. FISCHER. *Acustica*, **1**, 35–9 (*No.* 1, 1951) *In German.*

When impulses are radiated from a rigid disk a distortion occurs which is a function of the direction of radiation, for the individual components in the spectrum of the impulse have different direction characteristics, depending on the frequency. Calculation shows that a radiated unit impulse can be considered as composed of partial impulses from surface-elements of the disk and is conditioned by the shape of the latter. With a given impulse form a resultant effect of the shapes of the impulse and of the disk is obtained. A.

534.232

1573. The absorption surface of acoustic radiators and groups of radiators. F. A. FISCHER. *Akust. Beih., No.* 1, AB 7–AB 8 (1951) *In German.*

The absorption surface of an acoustic radiator of arbitrary size is calculated as a function of the wavelength and its relation to Stenzel's compression factor is demonstrated. A.

534.232

1574. On the relation between directivity factor and amplitude distribution in linear and plane radiation systems. F. A. FISCHER. *Akust. Beih., No.* 1, AB 9–AB 11 (1952) *In German.*

The general relations are discussed for continuous and discontinuous radiators. A.

534.232

1575. Synchronisation of air-jet generators with an appendix on the stem generator. J. HARTMANN AND E. TRUDSØ. *K. Danske Vidensk. Selsk. Mat.-fys. Medd.*, **26**, 39 *pp.* (*No.* 10, 1951).

Following a review of earlier experiments on synchronization with a view to facilitating production of wave fields of large intensity, tests are described with adjustable twin-generators and with two entirely independent generators. Results and photographs of the wave pattern are given. An appendix describes the construction and performance of a new stem-generator, which avoids the heavy coupling between the nozzle and the oscillator and simplifies construction. G. F. HODSMAN

534.232

1576. The air-jet generator as a means for setting up waves in a liquid medium. J. HARTMANN AND F. LARRIS. *K. Danske Vidensk. Selsk. Mat.-fys. Medd.*, **26**, 26 *pp.* (*No.* 11, 1951).

The construction of a suitable generator is described and an estimate made of the power which can be transmitted into a liquid medium. Attempts to measure the intensity of the waves in the liquid are described and experiments on the production of emulsions, the effects on suspensions and biological effects are mentioned. G. F. HODSMAN

534.232 : 534.133 : 621.396.611.21

1577. Power output measurements of ultrasonic quartz crystals. W. SCHMITZ AND L. WALDICK. *Z. angew. Phys.*, **3**, 281–8 (*No.* 8, 1951) *In German.*

A theoretical treatment, based on the impedance function, of the different sources of energy dissipation of a vibrating quartz crystal is described. An equivalent circuit diagram is derived which suggests ways of compensating for certain losses when measuring the radiation output. The principles of a circuit embodying these compensation methods is described and some results are quoted for a crystal vibrating in air and in water which demonstrate the importance of the coupling factor. H. J. H. STARKS

534.26

1578. The diffraction of sound by circular apertures. T. NIMURA. *Sci. Rep. Res. Inst. Tôhoku Univ. B*, **1–2**, 381–9 (*March*, 1951).

A mathematical paper making use of spherical co-ordinates and spheroidal wave functions. A rigorous theory of the diffraction of plane sound waves by a circular aperture in an infinitely large and thin rigid wall is developed when the radius of the diffraction aperture is of the same order of magnitude as the wavelength. The results indicated numerically and graphically are (1) the sound fields in the neighbourhood of an aperture, (2) the directional characteristics, (3) acoustic impedances, and (4) transmitted power through an aperture. Agreement is shown with the theory of H. Lamb and the experiments of M. J. O. Strutt. A. B. WOOD

534.26

1579. The scattering of sound from a prolate spheroid. R. D. SPENCE AND S. GRANGER. *J. Acoust. Soc. Amer.*, **23**, 701–6 (*Nov.*, 1951).

Presents the results of calculations of the scattering of a plane sound wave from a prolate spheroid. Scattering patterns are given for the major axis equal to λ/π, $2\lambda/\pi$, $3\lambda/\pi$, for the ratio of axes equal to 0·10, 0·20, 0·29, 0·37, and for the angle of incidence measured from the major axis equal to 0°, 30°, 60°, 90°. A.

534.321.3

1580. Scales and equal temperament. A. D. FOKKER. *Acustica*, **1**, 28–35 (*No.* 1, 1951) *In French.*

Two examples are given to show the way in which Euler provided a foundation for the grammar of musical scales; the *genus diatonicum* (common major and common minor scale) and the *genus chromaticum* (gipsies' scale and six-note scale of whole tones). By quotations from Haba and Bartok it is pointed out that the common equal temperament of 12 semi-

tones is no longer adequate for autochthonic and modern music. From a mathematical formulation of the requirements an equal temperament of 31 fifths of a tone per octave is derived. This is Huygens's solution. Figures of F.-K. Ligtenberg are given showing the relative degree of "shortcoming" of the best possible temperaments in the range from 10 to 60. Only Mercator's temperament of 53 is superior to Huygens's of 31. Reasons are given for the choice of an elementary unit of 38·65 cents instead of 38·71 (= 1 200/31) cents. The keyboard of an organ realizing the 31 fifths temperament is described. A.

534.321.9

1581. Ultra-sonic waves in air and their applications. F. CANAC AND V. GAVREAU. *Acustica*, **1**, 3–16 (*No.* 1, 1951) *In French.*

Advantages are discussed and the following topics considered: possibility of use for studies on models without requiring an anechoic room; emitters and receivers used; reflection and diffusion by cylinders and by polycylindric surfaces; experimental results; quantitative and qualitative recording of sound fields; apparatus used; application to the study of the sound reflected by simple surfaces; application to the study of acoustics of rooms; distribution of sound intensities (with fixed source and moving microphone or with fixed microphone and moving source); images of progressive sound waves. A.

534.37 : 532.623

1582. On the thermal damping of bubbles of various gases in water. H. LAUER. *Akust. Beih., No.* 1, AB 12–AB 24 (1951) *In German.*

The causes influencing the damping of spherical oscillations of gas bubbles in water are calculated, especially those due to thermal effects within the bubble when it is placed in an acoustic field. The thermal conductivity of the gas is an important factor of the damping. Measurements on resonance-bubbles of the gases air, H, A, Ne and He in the frequency-range from 1 to 7 kc/s are in good agreement with theory. A.

534.37 : 532.623

1583. Measurement of the damping of oscillating air bubbles in water. M. L. EXNER. *Akust. Beih., No.* 1, AB 25–AB 33 (1951) *In German.*

A new technique has been developed by which the bubble is allowed to rise freely in a water-filled tube under the influence of a plane progressive wave. Reflection of this wave from the free surface is prevented by an absorption device. The bubble acts as a centre of reflection and as it passes a microphone, the pressure distribution before and behind the bubble is registered. From the reflected power, measured in this way, the damping factor for the bubble may be estimated. From measurements made for the case of resonance, it appears that within the frequency range of the experiment the damping of the bubble may be completely explained through the effects of heat transfer and radiation. A.

534.372

1584. Transmission of mechanical vibrations through rubbers. R. E. MORRIS, R. R. JAMES AND H. L. SNYDER. *Industr. Engng Chem.*, **43**, 2540–7 (*Nov.*, 1951).

The purpose of this investigation was to determine how simple compression mountings for machinery compare with regard to transmission of mechanical vibrations when the mountings are made from different rubbers. The only difference between the mountings was the rubber contained; all mountings had the same physical dimensions, the same static modulus, and essentially the same hardness. Natural rubber was found to transmit less vibrational force than any of the other rubbers in the range of frequencies from 25 to 2 000 c/s; moreover, its transmissibility was practically constant over this range of frequencies. Neoprene Type FR transmitted a little more force than natural rubber. Its transmissibility also remained practically constant over the frequency range except for a rise at low frequencies. The transmissibilities of all other synthetic rubbers tested were higher and increased with rising frequency over the entire range. A.

534.39

1585. Erratum: The theory of steady forces caused by sound waves. P. J. WESTERVELT. Letter in *J. Acoust. Soc. Amer.*, **23**, 719 (*Nov.*, 1951).

See Abstr. 5210 (1951).

534.39 : 532.528 : 541.15

Reaction sites in field of stationary ultrasonic waves. *See Abstr.* 2204

534.41

1586. The sound film spectrograph—an instrument for acoustic analysis of speech sounds and other rapidly varying sound phenomena. B. H. EDGARDH. *IVA [Stockholm]* **22**, 134–53 (*No.* 5, 1951) *In German.*

The Swedish sound-film spectrograph consists of four groups of instruments, the projector section, the amplifier system, the wave analyser and the spectrograph camera. The record, made on 35 mm film, is intensity modulated, the frequency range (across the film) extending from 200 c/s to 6 kc/s (in 40 steps). The author's spectrograph is compared with the American visible-speech-spectrograph. It is stated that the latter can analyse speech only for 2·4 sec, whilst the former can deal with speech lasting 5 minutes. Another improvement introduced into the Swedish spectrograph relates to the intensity modulation of 40 "spectrum" lines in the record.

A. B. WOOD

534.6

1587. Pulse technique for the reciprocity calibration of microphones. R. L. TERRY AND R. B. WATSON. *J. Acoust. Soc. Amer.*, **23**, 684–5 (*Nov.*, 1951).

Describes a pulse technique which makes possible a free-field reciprocity calibration of a microphone indoors, without recourse to an anechoic chamber. The method is limited to frequencies above the middle audio range by consideration of the room size and pulse spectrum. An experimental calibration of a microphone is included, and waveforms are presented which demonstrate the validity of the method. A.

534.6 : 621.317.39 : 621.396.615

1588. Equipment for acoustic measurements. II. A portable tone source developed for use in room acoustics. C. G. MAYO AND D. G. BEADLE. *Electronic Engng*, **23**, 368–73 (*Oct.*, 1951).

For Pt I, see Abstr. 145 (1952). A novel beat-frequency oscillator covering the range 20–

20 000 c/s is described. To obtain a logarithmic scale with a sufficiently small variable capacitor, a 3-terminal capacitor in the form of a piston attenuator is used. As, however, the transfer capacitance is too small for direct use, the unit is connected across the input and output terminals of the oscillator, so increasing the effective capacitance by Miller effect. Pot-type ferrite cores are used for coils giving high Q-factor and good magnetic screening but requiring thorough heat insulation to reduce changes due to temperature rise. The variable oscillator consists of two valves acting as the oscillator proper followed by an amplifier stage and a 7 c/s transitron oscillator which provides the warble tone by altering the effective variable capacitance through gain variation. The fixed oscillator is conventional and operates at 150 kc/s. It is, however, self-regulating by control of the suppressor-grid potential and by suitable division of anode and screen currents. Harmonic suppression is effected by heavy cathode feedback. Purity of a.f. output is ensured by squaring the waveform of the variable-frequency oscillator and mixing it with the pure fixed-frequency output in a linear rectifier. The 2-stage a.f. amplifier is conventional. A motor-drive and 4-speed gear box enables the whole frequency range to be covered in a 4, 8, 16 or 32 min glide. The instrument weighs < 20 lb. Design details of the variable capacitor and performance figures are given. H. G. M. SPRATT (R)

534.6 : 621.396.615.17 : 621.317.755

1589. Equipment for acoustic measurements. III. Acoustic pulse measurements. C. G. MAYO, D. G. BEADLE AND W. WHARTON. *Electronic Engng*, **23**, 424–8 (*Nov.*, 1951).

The equipment consists of a triggered time-base oscilloscope, a combined tone pulser and a.f. amplifier and an a.f. oscillator, of which the first two items only are studied. The oscilloscope incorporates a delay unit and a time base, both utilizing the Miller integrator principle, and their operation is described in detail. In both circuits the square waveform from the screen grid is used, after differentiation, as a trigger pulse, that from the delay circuit to drive the time base, and that from the time base to trigger the delay circuit when self-running operation is employed. The waveform from the time-base suppressor grid is used for flyback suppression. The Y-plate amplifier, which is fed from a microphone, and the c.r.t. supplies are conventional but a long after-glow c.r.t. is employed. The tone pulser also includes 2 Miller integrators, one of which triggers the oscilloscope time base and the electronic switch, while the other is the electronic switch itself. The latter circuit receives tone from an external a.f. oscillator and converts it into pulses of known length which pass through the a.f. amplifier to a loudspeaker. The equipment is used for testing the acoustic characteristics of auditoria. H. G. M. SPRATT (R)

534.6 : 621.317.39

1590. Equipment for acoustic measurements. IV. The direct measurement of reverberation time. C. G. MAYO AND D. G. BEADLE. *Electronic Engng*, **23**, 462–5 (*Dec.*, 1951).

The test is carried out by passing the sound pick-up, either warble tone or noise, through a logarithmic amplifier and detector, the output being displayed on a c.r.t. The reverberation time is read directly off a special scale, the time base of the c.r.t. being calibrated by means of a damped wave of known decrement passed through the logarithmic amplifier. The amplifier unit consists of a head amplifier followed by two push-pull variable-μ stages, rectifier and voltage regulator stage. The "log" output is taken from a resistive network in the cathode-grid circuits of the variable-μ stages and passed through a cathode-follower power stage. Another unit contains the decay calibrator and a noise generator. The decay calibrator is a 2-valve oscillator to which various fixed resistors can be applied to give known decrements. The noise generator is provided with a switchable 3 db/octave filter, so providing either "pink" or "white" noise. A special circular scale is fitted to the c.r.t. for calibration adjustment. In actual reverberation tests the sound source is used in conjunction with the tone pulser described in the preceding abstract. H. G. M. SPRATT (R)

534.614

1591. Measuring frame with a number of Rayleigh disks arranged in a square network to increase sensitivity. L. KEIDEL. *Akust. Beih., No.* 1, AB 34–AB 36 (1951) *In German.*

The Rayleigh disks of very small diameter as still used to-day in connection with absolute calibrations in ultrasonics are very insensitive. The writer points out that a number of equally-sized Rayleigh disks, if assembled on a fine-mesh grid, may be used for creating a multiple of the torque of each individual disk. The space between the individual disks must be sufficiently large to prevent one disk being influenced by the next. A.

534.632

1592. The further development of the pitch-recorder with application in phonetic investigations. W. KALLENBACH. *Akust. Beih., No.* 1, AB 37–AB 42 (1951) *In German.*

The pitch-recorder, developed by Grützmacher and Lottermoser, allows pitch-recording of speech and singing without delay. This is done by photographic recording of a saw-tooth-oscillation, synchronized with the basic frequency of the speech sound, appearing on the screen of a cathode-ray tube. An arrangement is described which allows discrimination of vowels and consonants by altering the brightness of the electronic beam in such a way as to give a representation of the speech characteristics. A.

534.632

1593. A frequency analyser with mechanical high note filter. K. TAMM AND I. PRITSCHING. *Akust. Beih., No.* 1, AB 43–AB 48 (1951) *In German.*

A heterodyne frequency analyser having for a given technical expenditure an optimum frequency discrimination, amplitude range (dynamic) and speed of analysis is described. For separating two components lying close together and having a large difference in amplitude level, an ideal band-pass filter is more suitable than a single resonance circuit of equal transient time which limits the speed of analysis. Using a mechanical 40 kc/s band-pass filter, consisting of two coupled steel resonators (Tonpilze) of low

damping, a transmission curve of bandwidth 15 c/s was obtained which is able to separate two frequency components differing 40 db in level and only 25 c/s in frequency. Sound components down to 65 db below the maximum level can be indicated without any distortion through noise or harmonics generated by the apparatus itself. When using the automatic drive the time of analysis for the frequency range 0 . . . 20 kc/s is 150 s corresponding to the highest possible speed of analysis. A number of analyses recorded by a logarithmic recorder are shown. A.

534.771

1594. C.I.D. auditory tests W-1 and W-2. R. W. Benson, H. Davis, C. E. Harrison, I. J. Hirsh, E. G. Reynolds and S. R. Silverman. Letter in *J. Acoust. Soc. Amer.*, **23**, 719 (*Nov.*, 1951).

Describes a number of new auditory tests used at the Central Institute for the Deaf (St. Louis, Missouri). These consist of simple words, suitable for adults and children alike. The 36 words are "scrambled" in six different ways by cutting and splicing magnetic tape on which they were recorded and then re-recorded under various conditions (intensity control, attenuation, etc.) on 12-inch disks. A. B. WOOD

534.78

1595. The representation of time-frequency spectra in relief by photographic differentiation. V. W. Meyer-Eppler. *Akust. Beih., No.* 1, AB 1–AB 3 (1951) *In German.*

The spectral distribution of energy both in frequency and time is usually portrayed by dark or bright patterns of varying shades. A third method is suggested here: relief portraying, which represents not only the spectral amplitude but also its time derivative, giving a considerably higher resolution of fine structures. The process uses photographic differentiation and is applicable to any continuous spectrogram. The normal portrayal may also be adapted for use by this method. A.

534.78

1596. The intervalgram as a visual representation of speech sounds. S. H. Chang, G. E. Pihl and J. Wiren. *J. Acoust. Soc. Amer.*, **23**, 675–9 (*Nov.*, 1951).

The points of zero crossing and the points of zero slope of the oscillograms of speech sounds are considered to contain the essential information for intelligibility. The intervals between zero crossings θ_0, and the intervals between zero slopes θ_m, are plotted as points in rectangular co-ordinates. The ordinate of the dot is a function of θ (θ_0 or θ_m), and the abscissa is a function of the time of occurrence t of the particular θ. The resulting intervalgram gives a half-tone picture (consisting of dots) of speech sounds. The patterns may be proportioned to show either a detailed or general representation of the variation of the interval distribution. One type of pattern portrayed at the speech rate on a cathode-ray oscilloscope with a screen of long persistence has been found quite similar in certain respects to the patterns obtained using the sound spectrograph as described in the book *Visible Speech* by Potter, Kopp and Green. The equipment involved in obtaining the intervalgram, however, is much simpler. A.

534.784 : 534.63

1597. Frequency detection and speech formants. E. Peterson. *J. Acoust. Soc. Amer.*, **23**, 668–74 (*Nov.*, 1951).

Aims primarily at evaluating the utility of axis-crossing detectors in tracking speech formants. Detectors of the usual type are found subject to an error, fundamental in nature. To remove this source of error speech is modulated up in frequency as a single sideband before limiting and detecting processes are applied. Experimental results with this carrier type of detector on a small number of speech samples are presented, and compared with spectrograms. Conclusions are that the average axis-crossing rates cannot be trusted in general to follow specific formants, whether the speech is normal or differentiated. But when the formants are sufficiently localized by frequency selectivity, prospects of tracking the lower formants look promising. A.

534.833

1598. A tentative method for the measurement of indirect sound transmission in buildings. E. Meyer, P. H. Parkin, H. Oberst and H. J. Purkis. *Acustica*, **1**, 17–28 (*No.* 1, 1951).

The amplitude and its distribution on all the surfaces of the receiving room are determined using small piezoelectric accelerometers, vibration measurement at 6 points of each wall being sufficient in the case of statistical sound fields. The airborne sound source is then replaced by vibration transmitters attached to the walls of the source room which are adjusted in position, number and amplitude of vibration such that the pattern and amplitudes of normal vibration of all the surfaces of the receiving room are as similar as possible to those obtained with airborne excitation. In the next stage the transmitters at the party wall are removed and the sound pressure level in the receiving room is measured. The total indirect energy transmitted to the receiving room by different paths can thus be measured in several steps. The accuracy of the method, which requires improvement, allows measurement of the levels of the important parts of energy with an error of about $\pm$ 1·5 db. The results obtained to date in normal buildings confirm that with Sound Reduction Factors of party walls of about 50 db the direct and indirect energy are of the same order of magnitude; above this value indirect transmission is of decisive influence. A.

534.833

1599. Symbols and nomenclature in sound insulation. C. W. Kosten, J. v. d. Eijk, M. L. Kasteleyn, G. J. van Os and P. A. de Lange. *Acustica*, **1**, 78–80 (*No.* 2, 1951).

A logical and unambiguous system is proposed for the symbols and names used in the provisional code for sound insulation measurements. The objections to the current symbols contained in the English, French and German texts of the code are put forward, and the advantages of the proposed system are mentioned. A.

534.837 : 621.314.2 : 621.311.42

1600. An investigation of audio noise in substation-type transformers. J. H. Vivian and R. R. Peck. *Trans Amer. Inst. Elect. Engrs*, **70**, 328–32 (*Pt I*, 1951).

The tendency to use unit-type substations in resi-

dential areas for economic reasons has focused attention on the nuisance created by transformer noise and shown that present noise standards are too high. The paper gives results of tests made to determine the causes of sound radiation and the effectiveness of various forms of sound barrier. Ambient noise level varies from 30 to 90 db above zero in residential and industrial areas, and transformer noise must be about 8 db below ambient at any instant to be unnoticeable. Although sound barriers may be used to control noise, the ultimate method must be to eliminate noise generating sources in the apparatus. See also following abstract.

B. B. AUSTIN (R)

534.837 : 621.314.2 : 621.311.42

1601. Acoustic models of transformer installations. B. GETTYS AND W. B. CONOVER. *Trans Amer. Inst. Elect. Engrs*, **70**, 333–8 (*Pt I*, 1951).

The information required for the reduction of noise radiated by transformers in urban districts cannot be easily obtained analytically. The use of acoustic models enables satisfactory results to be quickly and cheaply obtained. The acoustic model technique is described with block schematic and typical graphs of results are shown. A summary of some of the results is given. B. B. AUSTIN (R)

534.843

1602. Investigation of sound diffusion in rooms by means of a model. T. SOMERVILLE AND F. L. WARD. *Acustica*, **1**, 40–8 (*No.* 1, 1951).

An investigation of the sound distribution in enclosures having diffusing elements fixed to the boundary surfaces has been carried out by means of a model. The experiment was in two parts: an assessment of the irregularity of the steady-state characteristic, and of the amplitude irregularity of short pulse displays on a cathode-ray oscilloscope. All three forms of diffusing elements used gave a reduction in steady-state and pulse irregularity, but the greatest reduction was obtained from rectangular diffusers. Cylindrical and triangular elements were not so effective. A.

534.843

1603. Sound régime of a room after the extinction of the source. M. BARKECHLI. *Acustica*, **1**, 59–74 (*No.* 2, 1951) *In French.*

When a source of sound, acting in a room, is suddenly stopped, a free regimen sets up, the extinction of which the elementary theory predicts, following an exponential law with an attenuation which depends only upon the volume of the room and the total absorption of its lining. A theoretical study, followed by experimental verification, has shown that in a parallelepiped-shaped room with located absorption, the reverberation time changes with the position of the absorbent. The theory of Sabine is insufficient for measurement in the laboratory of coefficients of absorption. However, it gives the only usable approximation for high-pitched sounds. For low enough frequencies the author develops a more precise theory, making it possible to predict the variations of the reverberation time. A.

534.843.5

1604. On the influence of a single echo on the intelligibility of speech. H. HAAS. *Acustica*, **1**, 49–58 (*No.* 2, 1951) *In German.*

An apparatus has been built to produce known time delays between the direct sound and its echo. When the delay is small the loudness of the received sound is increased and a pleasing modification of timbre produced. Long delays cause distortion leading to complete lack of intelligibility. In this connection the concept of a "critical delay difference" is introduced. It is a function of echo intensity, spectrum of source and reverberation time of the experimental room. A.

534.845.1

1605. Tentative recommended practice for laboratory measurement of airborne-sound transmission loss of building floors and walls. A. LONDON. *J. Acoust. Soc. Amer.*, **23**, 686–9 (*Nov.*, 1951).

The American Society for Testing Materials recently promulgated the tentative recommended practice reproduced in this paper. As far as is known this is the first successful tentative standard which has been adopted in the field of architectural acoustics in The U.S.A., even though standardization efforts along these lines go back to the late 1930's. A.

534.846.4 : 621.395.623

1606. Speech-reinforcement system evaluation. L. L. BERANEK, W. H. RADFORD, J. A. KESSLER AND J. B. WIESNER. *Proc. Inst. Radio Engrs*, **39**, 1401–8 (*Nov.*, 1951).

Speech-reinforcement systems in six large auditorias were evaluated, using subjective rating tests, word-articulation tests, and, in two cases, a new test method. This method, called the "terminal-word test," makes possible the quantitative measurement of speech intelligibility for a sound system in actual use. A graphical method is presented for calculating the performance of a sound system in which account is taken of the frequency response of the system, the reverberation time of the room, the directivity index of the loudspeaker, and the room noise. Test results indicate that a flat frequency response in the range between 400 and 4 000 c/s is required for good intelligibility. The graphical method indicates that little further increase in intelligibility would result from extending this range upward or downward. If the loudspeaker system is sufficiently directive in this frequency range and properly located in the room, room reverberation has little effect on speech intelligibility. A.

OPTICS . RADIATION . SPECTRA 535

535.214.4

1607. The panradiometer: an absolute measuring instrument for environmental radiation. C. H. RICHARDS, A. M. STOLL AND J. D. HARDY. *Rev. Sci. Instrum.*, **22**, 925–33 (*Dec.*, 1951).

The instrument consists of four hollow, silver spheres 6 mm in diameter, of identical construction; one sphere is painted black, one white, and the remaining two are highly polished. Each is provided with a thermocouple for measuring its temperature,

and an internal heating coil for adjusting its temperature. Total environmental thermal radiation intensity is obtained by measuring the heat input to the two spheres of lower temperature to bring the black, white and one polished sphere to the same temperature when the instrument is exposed in a given environment. The second polished sphere provides for wind velocity measurements after the manner of a sphere anemometer. Measurement of direct solar radiation exclusive of reflected and scattered solar radiation is made by comparing the total radiation in sunlight with that obtained when the spheres are shaded from the sun. The radiant temperature of the environment is obtained by correcting the measured value of total radiation for the effect of solar radiation. A precision of ± 4% can be realized for the measurement of solar radiation and of ± 1·8°C for the measurement of the radiant temperature of the surroundings. A.

535.224

1608. Research on the velocity of light reflected from metals. Q. MAJORANA. *Atti Accad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **11,** 10–17 (*July–Aug.*, 1951) *In Italian.*

A modified Michelson interferometer is used to determine small differences in velocity of the light reflected from metal surfaces, these being evaporated upon plane glass surfaces. Differences up to 34 m/sec have been found. R. W. FISH

535.23 : 537.311.33

Optical constants of germanium, silicon and pyrite in the infrared. *See Abstr.* 996

535.23.08

1609. Study of the response of a bolometer subjected to modulated radiation. M. SURDIN. *J. Phys. Radium,* **12,** 37 A–40 A (*Oct.*, 1951) *In French.*

A theoretical study of the output of a bolometer subjected to radiation interrupted at various frequencies, output being measured with the aid of a valve amplifier. Output was shown to rise as the time of cooling decreased, and experiments using a bolometer consisting of an electro-deposit of Pt on mica agreed well with theory. The amplifier is described, and the effect of the thermal wave emitted from the bolometer is shown to be negligible. It is suggested that for practical purposes, an instrument with a much faster cooling rate, such as a deposit of graphite on a film of collodion or nylon would be necessary to give an easily measurable output.

W. C. MOSS

535.24

1610. Photometric teaching methods using photoelectric cells. U. ANDREWES AND T. J. DILLON. *Amer. J. Phys.*, **19,** 514–19 (*Dec.*, 1951).

Construction details of 3 photometers, designated as black box, integrating, and hoop types, are given. All photometers use photovoltaic cells as the light-measuring devices. Tests made with these photometers upon filament-type lamps and fluorescent discharge tubes establish the mean horizontal candle power and the mean spherical candle power of light sources normally found in the laboratory. Auxiliary experiments are described for determining the range of validity of the inverse square and cosine laws for the light sources. A table lists the luminous flux for several sources, measured by each type of photometer. A.

535.247.4

1611. Series-aiding phototube bridge. L. G. GLASSER. *Science,* **114,** 360–1 (*Oct.* 5, 1951).

This is a stable, high-precision, high-sensitivity photometer using a Wheatstone bridge arrangement. At 90 V across the bridge the sensitivity is 7 V for 1% change of light intensity. Reproducible measurements can be made down to 0·001% absorption.

W. SUMMER

535.247.4 : 621.383 : 621.317.79

1612. Feedback photometer speeds light measurements. J. E. TYLER. *Electronics,* **24,** 92–3 (*Dec.*, 1951).

An out-of-phase oscillatory twin photocell instrument is described, which indicates bridge unbalance and can also serve as a light source for comparison measurements and as a densitometer. The optical system contains a standard reference lamp in a light-tight housing, an integrating sphere, an attenuator wedge, a circular stop with focusing lens for reflectance investigations and a second lens system in a rotatable disc for transmission measurements. A. LANDMAN

535.247.4 : 541.182.3

1613. The photoelectric measurement of coal dust stains on filter paper. C. N. DAVIES AND M. AYLWARD. *Brit. J. Appl. Phys.*, **2,** 352–9 (*Dec.*, 1951).

Deposits of coal dust collected on filter paper from airborne clouds have been studied in connection with their light screening power. This depends on the nature of the paper as well as the size and concentration of the particles. Nine kinds of paper were investigated, two of them in detail. Some idea has been obtained of the qualities necessary in a filter paper in order that the dust deposits will have maximum optical density. Theoretical expressions are derived for light screening according to how the particles are dispersed in the paper. Maximum screening would result if each particle shadowed individually, but this is only possible in very sparse deposits; otherwise, overlapping of the particles has to be allowed for. Diffraction of light by the particles and the effects of diffusion of light in the paper are discussed. A.

535.315

1614. Distortion of the image by prisms. K. N. OGLE. *J. Opt. Soc. Amer.*, **41,** 1023–8 (*Dec.*, 1951).

The distortion of the image formed by a prism, principally an ophthalmic prism, is shown to be adequately described quantitatively by five parameters. Expressions are derived which relate the physical constants of the prism and the position of the prism before the eye to these five parameters. Comparisons of measurements and theory are given. This theory is useful for the study of this distortion and for designing prisms with a minimum of certain aspects of this distortion. A.

535.318

1615. The control of Petzval curvature. W. WALLIN. *J. Opt. Soc. Amer.*, **41,** 1029–32 (*Dec.*, 1951).

It is generally recognized that an anastigmatic lens

system has a relatively fixed amount of field curvature associated with its focal length. The present paper investigates the manner in which indices of refraction, thicknesses, and separations may be used to gain some control over Petzval curvature independently of back focal length. A.

535.321

1616. The measurement of refractive index gradients in small glass specimens. J. W. GATES. *J. Sci. Instrum.* **28,** 370–2 (*Dec.*, 1951).

The refractive index gradient from point to point along the length of a specimen about 20 mm × 5 mm × 1 mm is determined from the relative deviations of incident parallel pencils of light. The effect of imperfections in the bounding surfaces of the specimen is reduced by immersing the specimen in a liquid of suitable refractive index. A.

535.321.5

1617. The refractive index of thin Al_2O_3 films. W. WEISKIRCHNER. *Z. Naturforsch.*, **6a,** 509–10 (*Sept.*, 1951) *In German.*

The films described by Strohmaier [Abstr. 2156 (1952)] are investigated, refractive index measurements being made by the immersion method. The refractive index is found to be linearly proportional to film thickness in the thickness range studied (1 233–2 740 Å). Values are reported from 1·567 to 1·614. Ageing over 2 months made no difference to the observed indices. S. TOLANSKY

535.321.53

1618. A highly sensitive phase-contrast refractometer for liquids and gases. E. INGELSTAM. Letter in *Nature* [*Lond.*] **168,** 960 (*Dec.* 1, 1951).

This phase-mirror refractometer determines relative refractive indices to 5×10^{-8} and uses only 0·1 cm^3 of liquid. See Abstr. 164 (1952). R. W. FISH

535.322.4

1619. A differential refractometer. B. A. BRICE AND M. HALWER. *J. Opt. Soc. Amer.*, **41,** 1033–7 (*Dec.*, 1951).

The design and performance of an absolute deviation type of differential refractometer is described. The apparatus comprises mercury and sodium lamps, monochromatic filters, slit, differential cell, projection lens, and micrometer microscope, all accurately aligned on an optical bench. The cell is square with a thin partition separating solution and solvent, such that the angle of incidence is about 69° on the interface. The cell and its holder, in a jacketed housing, can be turned through 180° in order to interchange solvent and solution and approximately double the deviation. By ray tracing it is shown that the distance between the slit images in the eyepiece field, Δd, is accurately proportional to the difference in refractive index, Δn, of solution and solvent, and that the factor of proportionality can be evaluated from accurately measurable geometrical quantities: the cell partition angle, the virtual distance from slit to cell centre, and the magnification of the system up to the field of the micrometer eyepiece. The range of the instrument is approximately 0·01 unit and the limiting sensitivity about 3×10^{-6} unit of refractive index difference. The accuracy in determination of Δn is about 0·5%. The instrument is useful for determination of small differences in refractive index or concentration, and for determination of refractive index increments needed in the light-scattering method of evaluating high molecular weights. A.

535.325–15 : 539.133

Infrared dispersion of acetylene. *See Abstr.* 2026

535.327

1620. The dispersion and thermo-optic behaviour of vitreous silica. S. CHANDRASEKHAR. *Proc. Indian Acad. Sci. A,* **34,** 275–82 (*Oct.*, 1951).

The refractivity and the dispersion of vitreous silica are shown to be calculable from those of quartz by considering the diminished density. The temperature variation of its refractive indices over the entire range of wavelengths is in quantitative accord with the hypothesis that the characteristic absorption frequencies in the ultra-violet fall with rise of temperature. The rate of change of these frequencies has been traced from − 160° to 1 000°C and shows remarkable variations in the vicinity of the temperature at which the α–β transformation in crystalline quartz occurs. A.

535.33.07

1621. A microspectrophotometer equipped with photo multipliers. P. W. LANGE AND Å. S. STENIUS. *Rev. Sci. Instrum.*, **22,** 865–8 (*Dec.*, 1951).

A spectrophotometer, equipped with photomultiplier tubes, is described for the wavelength range 2 500–7 000 Å. The apparatus is intended for the determination of light absorption in microscopic objects and is especially useful for studies of biological material. The guiding principle of the construction is that the object in the course of the measurement should have a fixed position. Some applications concerning studies of small parts of cellulose and wood fibres are given. The weight of the examined samples has been between 10^{-10}–10^{-12}g. A.

535.33.07 : 535.421

1622. A grating spectrophotometer for the ultraviolet and visible regions. T. B. THOMAS AND E. E. SCHNEIDER. *J. Opt. Soc. Amer.*, **41,** 1002–5 (*Dec.*, 1951).

For absorption spectrophotometry extending into the far ultra-violet, a diffraction grating presents advantages over a quartz prism because of its uniform dispersion. A wide range photoelectric spectrophotometer, which employs a plane diffraction grating (5 700 lines/cm) as dispersing element, a single concave mirror for collimating and focusing, and narrow fixed slits (70 μ) is described. A commercial H lamp and a small W filament lamp serve as light sources for the ultraviolet and visible regions. The sensitive detector consists of a vacuum photocell followed by an electrometer valve and galvanometer in a bridge circuit. By carefully designed baffles, stray light is reduced to an amount which, at wavelengths above 2 100 Å, is negligible compared with the monochromatic output. The residual stray light, entirely caused by scatter from the grating and mirror surfaces, can be determined by adjusting the grating angle to a nominal wavelength setting below 1 800 Å. It is shown that on this basis a reliable correction can be applied to the absorption measure-

ments below 2 100 Å which extends the useful range of the instrument down to at least 1 900 Å. The present long wave limit of the instrument, determined by the response of the photocell, is 6 000 Å. Tests with a line source have shown that the wavelength calibration, based on the grating formula, is correct to within 5 Å, and that the spectral band width is about 8 Å throughout the whole range. The use of the instrument for absorption measurements of alkali halide crystals, of which an example is given, has demonstrated its accuracy and reliability. A.

535.33.07–14

1623. Microwave spectroscopy in the region from two to three millimeters. II. C. M. JOHNSON, R. TRAMBARULO AND W. GORDY. *Phys. Rev.*, **84**, 1178–80 (*Dec.* 15, 1951).

For Pt I, see Abstr. 6379 (1950). Precise frequency measurements have been made on rotational transitions occuring in the wavelength range from 2 to 3 mm for a number of molecules. From these, centrifugal stretching effects have been determined and accurate values of the rotational constants obtained. A table including all frequencies so far measured in this region of the spectrum is given. A.

535.33.07–15

1624. A microilluminator for the study of the infrared spectra of small samples at low temperatures. R. M. BADGER AND R. NEWMAN. *Rev. Sci. Instrum.*, **22**, 935–6 (*Dec.*, 1951).

An instrument is described which combines the functions of a reflecting microscope and a low temperature cell. It permits infrared absorption spectra to be obtained on single microcrystals at low temperatures, using polarized radiation. A.

535.33.07–15

1625. A method of calibrating an infrared prism spectrometer. W. L. ROSS AND D. E. LITTLE. *J. Opt. Soc. Amer.*, **41**, 1006–10 (*Dec.*, 1951).

This calibration method, developed for a Perkin–Elmer Model 12 spectrometer, covers the regions 5 to 15 μ (NaCl) and 2 to 5 μ (LiF). Standardized techniques lowered the standard deviation of the spectrometer itself to $0{\cdot}10\ \text{cm}^{-1}$ at $1\,000\ \text{cm}^{-1}$. The formula $T_i = T_0 + (a/\nu_i^2 - \nu_0^2)$ is shown to be analogous in form and method of solution to the Hartmann dispersion formula, $\lambda_i = \lambda_0 + (c/d_0 - d_i)$. Thus Hartmann formula techniques have been applied to the calibration equation. Solutions are readily handled on a calculating machine; graphical interpolations are obviated. The results have standard deviation of $0{\cdot}28\ \text{cm}^{-1}$ at $1\,000\ \text{cm}^{-1}$. A.

535.337 : 537.228.5

1626. The time- and pressure-dependence of the intensity-asymmetry in the Stark effect in hydrogen. R. GEBAUER AND G. OHL. *Z. Phys.*, **130**, 605–20 (*No.* 5, 1951) *In German.*

The effect has been studied for the lines $H\beta$ and H_γ, and a theoretical treatment in good agreement with experiment is given. The theory of the effect is based on the fluctuations in the excitation and emission processes as well as in collisions of the second kind. The solutions of the differential equations give the intensity ratio of long- and short-wavelength components of the gross Stark structure in terms of the path traversed by the canal beam in the field, i.e. in terms of the time (= path/velocity), in which the pressure appears implicitly as a parameter. The intensity-ratio increases exponentially with time to a limiting value. Reduction of the pressure decreases this limiting ratio, and simultaneously increases the time required for it to be established. The asymmetry increases with increasing collision diameter, and is accordingly greater for the outer-lying π-than for the inner-lying σ-components. Similarly, the asymmetry is greater for H_γ than for $H\beta$.

R. F. BARROW

535.338 : 523.4 : 551.593

1627. Forbidden transitions in the spectra of diatomic molecules. G. HERZBERG. *Astron. J.*, **56**, 118–19 (*Oct.*, 1951).

A survey of forbidden lines of 3 different types in various molecules which might be detected in astrophysical or geophysical sources, especially in planetary atmospheres. D. L. EDWARDS

535.338–15 : 537.523.4 : 551.594.221

1628. The near infrared spectrum of lightning. W. PETRIE AND R. SMALL. Letter in *Phys. Rev.*, **84**, 1263–4 (*Dec.* 15, 1951).

The spectrum in the 7 100–9 100 Å range obtained from a lightning flash is illustrated and analysed. This spectrum is compared with the spectra of argon and of a spark discharge. All the spectral features are found to be atomic in origin while molecular radiations are completely absent. R. H. GOLDE

535.338.3

1629. Term values in the $3d^5 4s$ configuration of Fe III. R. E. TREES. *Phys. Rev.*, **84**, 1089–91 (*Dec.* 15, 1951).

The theoretical formulae for d^5s are compared with the experimental data of Fe III. The mean deviation between theory and experiment is found to be $\pm 852\ \text{cm}^{-1}$. The values of the parameters B and G_2 which are required to give correctly the observed separations between certain pairs of terms were compared. Adding to the theory a correction term proportional to $L(L+1)$ leads to consistent values of all the radial integral parameters. The mean deviation between the theory corrected in this manner and experiment is reduced to $105\ \text{cm}^{-1}$. A.

535.338.333

1630. Isotope shift in erbium. L. WILETS AND L. C. BRADLEY, III. Letter in *Phys. Rev.*, **84**, 1055–6 (*Dec.* 1, 1951).

Measurements on 11 lines were carried out with a Fabry–Pérot interferometer. Both positive and negative shifts occur. $(\nu_{168}-\nu_{170})/(\nu_{166}-\nu_{168})$ is quite close to unity. L. PINCHERLE

535.338.334

1631. Pressure effects of argon and helium on the resonance lines of silver. E. D. CLAYTON AND S.-Y. CH'EN. *Phys. Rev.*, **85**, 68–70 (*Jan.* 1, 1952).

The shift and the broadening of Ag $\lambda\lambda$3280 and 3382 produced by A and He for pressures up to 83·3 atm. at about 950°c were determined. The shift of Pb 2833 was also measured under the same conditions. A produces a red shift and a slight red asymmetry, while He produces a violet shift and a very slight violet asymmetry for all these lines. The

$^2P_{\frac{1}{2}}$ component of Ag resonance lines is shifted more than the $^2P_{\frac{3}{2}}$ component. The relative difference in the shift is much more pronounced for He than for A. For He the $^2P_{\frac{1}{2}}$ component is shifted about 6 times more than the $^2P_{\frac{3}{2}}$ component. Both the shift and the broadening appear to be linear with the relative density for A or He. The $^2P_{\frac{1}{2}}$ component produces a shift of 0·289 cm^{-1} (red) per unit relative density of A, and of 0·131 cm^{-1} (violet) per unit relative density of He. The corresponding figures for the $^2P_{\frac{3}{2}}$ component are 0·248 cm^{-1} (red) and 0·023 cm^{-1} (violet) per unit r.d. Shifts for Pb 2833 are respectively 0·388 cm^{-1} (red) and 0·188 cm^{-1} (violet) per unit r.d. for A and He. There is no significant difference between the half-widths of the doublet components of the Ag lines for He. They are broadened 0·466 cm^{-1} per unit r.d. For A the $^2P_{\frac{3}{2}}$ component is broadened slightly more than the $^2P_{\frac{1}{2}}$ component. The $^2P_{\frac{1}{2}}$ and the $^2P_{\frac{3}{2}}$ components are broadened respectively 0·468 cm^{-1} and 0·560 cm^{-1} per unit r.d. The optical collision diameters as calculated from the half-widths turn out to be 6·50 Å for He–Ag and 11·3 Å for A–Ag. A.

535.338.4

1632. On a dissociation scheme for the spectrum of Co^+. P. K. Sen Gupta. *Indian J. Phys.*, **25**, 387–90 (*Aug.*, 1951).

A dissociation scheme has been proposed for the spectrum of CO^+ and correlated with the convergence limits of the known spectroscopic states. For the energy of dissociation of CO^+ the values 5·58 and 7·92 V have been considered likely according as the products of dissociation are $C^+(^2P) + O(^3P)$ and $C(^3P) + O^+(^4S)$ respectively. A.

535.338.4

1633. An emission band system attributed to the molecule NH^+. M. W. Feast. *Astrophys. J.*, **114**, 344–55 (*Sept.*, 1951).

Two red degraded bands at 2 725 and 2 885 Å have been excited in a hollow-cathode discharge tube in flowing ammonia. Their rotational structures have been analysed, and they are shown to be the (1, 0) and (0, 0) bands, respectively, of the $^2\Sigma^+ - {}^2\Pi_r$ transition of NH^+. Large perturbations in the $^2\Pi_r$ state are caused by a $^4\Sigma^-$ state. Wave numbers of the band lines and molecular constants for the three states are listed. Weaker bands at 2 614 and 2 825 Å probably belong to the same system. A.

535.338.4

1634. Spectroscopy of the solid state: potassium and calcium. R. H. Kingston. *Phys. Rev.*, **84**, 944–9 (*Dec.* 1, 1951).

Utilizing the techniques developed by O'Bryan and Skinner for the study of the emission bands of metals, it has been possible to determine the structure of the conduction bands of the metals, K and Ca. The spectrograph used utilizes a photomultiplier in place of a photograph plate, thus enabling higher sensitivity and ease of operation. The particular radiation studied is produced by transitions of the conduction electrons into the ionized 3*p* state of the atom. The limiting factor in the accuracy of the emission band obtained in this way is the purity of the sample studied. The contamination of the surface of an evaporated sample affects the resultant curve mainly as a result of insufficient penetration of the electrons, since the photon absorption is negligible at depths required to produce radiation representative of the pure bulk metal. The results for K and Ca at temperatures between 25°c and 100°c are not in good agreement with previous theoretical calculations. The experimental values of band width are 1·9 and 3·0 eV respectively, compared with the theoretical calculations of 3·6 and 5·0 eV. A.

535.338.4

1635. Spectra of flames burning with oxides of nitrogen. B. B. Fogarty and H. G. Wolfhard. Letter in *Nature* [*Lond.*] **168**, 1122 (*Dec.* 29, 1951).

Spectrograms have been taken of premixed gas flames of H_2, NH_3, CO and hydrocarbons burning with N_2O, NO and NO_2. The spectra of the hydrocarbon flames are generally similar, CH-, CN-, NH-, OH- and C_2-bands being present, but CO-fourth positive bands reported by Behrens and Rössler were not found. Some features of the combustion process in flames of (*a*) hydrocarbons with NO_2, (*b*) H_2–NO_2, (*c*) H_2–NO, and (*d*) NH_3–NO are briefly discussed. A. Schofield

535.338.4 : 539.132

Computation of the intensities of vibrational spectra of electronic bands in diatomic molecules. *See Abstr.* 2017

535.338.4 : 545.822

1636. Hydrocarbon flame spectra. G. A. Hornbeck and R. C. Herman. *Industr. Engng Chem.*, **43**, 2739–57 (*Dec.*, 1951).

Hydrocarbon flame spectra have been surveyed in the range ~ 2 000 to ~ 9 000 Å in order to establish the identity of band systems obtained under a variety of flame conditions. The sources and techniques required to enhance the spectra of specific molecular species by means of variations in oxygen-fuel ratio are described. The experimental results are presented chiefly in a selected series of densitometer tracings of bands obtained under a wide variety of oxygen-fuel ratios. The spectra of diatomic and polyatomic molecules, particularly the "hydrocarbon" and "deuterocarbon" flame bands, are discussed and some comments are made concerning the kinetic mechanisms involved. Several electronic ($^2\Sigma - {}^2\Pi$) OH bands are reported. The results provide the spectroscopic investigator of flames with a pictorial means of rapid identification. A.

535.338.4 : 551.594.5

An auroral spectrogram analysed. *See Abstr.* 2308

535.338.4 : 551.594.51

1637. Laboratory observation of the $A^2\Pi - X^2\Sigma$ bands of the N_2^+ molecule. F. W. Dalby and A. E. Douglas. Letter in *Phys. Rev.*, **84**, 843 (*Nov.* 15, 1951).

The Meinel bands [see Abstr. 7424 (1951)] have been obtained from a mixture of He + N_2 in a hollow-cathode tube. Band-head measurements are given. See also Abstr. 881 (1952). R. F. Barrow

535.339

1638. A simple monochromator. M. Heisler, C. Schmelzer and K. Schuhmann. *Z. Naturforsch.*, **6a**, 513–14 (*Sept.*, 1951) *In German.*

A monochromator is formed from a number of

uncorrected bi-convex lenses immersed in a liquid of similar refractive index but different dispersion. This lens-monochromator is shown to have a narrow spectral transmission band similar to that of an interference filter, although of greater transparency and movable throughout the visible spectrum.

R. W. FISH

535.343

1639. A variable thickness liquid absorption cell. V. J. COATES. Note in *Rev. Sci. Instrum.*, **22**, 853–4 (*Nov.*, 1951).

Constructional details are given of a cell of the piston and cylinder type, using a Teflon ring as a seal. The windows have a clear aperture of 25 mm and a maximum separation of 6 mm, with micrometer reading to 0·001 mm, and may be adjusted for parallelism.

R. W. FISH

535.343–14

1640. The microwave spectrum of methyl stannane. D. R. LIDE, JR. *J. Chem. Phys.*, **19**, 1605–7 (*Dec.*, 1951).

The microwave spectrum of methyl stannane between 25 500 and 29 000 mc/s is reported. All of the observed lines may be assigned to the $J = 1 \rightarrow 2$ rotational transitions of the isotopic species representing the five most abundant tin isotopes. The dipole moment was found from the Stark splitting to be $0{\cdot}68 \pm 0{\cdot}03$ Debye units. Insufficient information is available for a complete structure determination, but if tetrahedral angles and a C — H distance of 1·090 Å are assumed, the data can be fitted with a C — Sn distance of $2{\cdot}143 \pm 0{\cdot}002$ Å and a Sn — H distance of $1{\cdot}700 \pm 0{\cdot}015$ Å. The influence of hindered internal rotation on the spectrum is discussed.

A.

535.343–15

1641. Introduction to researches on the determination of the infra-red absorption spectra of organic ozonides. E. BRINER, B. SUSZ AND E. DALLWIGK. *Arch. Sci.*, **4**, 199–202 (*No.* 3, 1951) *In French.*

535.343–15

1642. Determination of the infra-red absorption spectra of the ozonides of: trans stilbene, styrene, anethole, benzene, naphthalene, cyclo-hexene, limonene. B. SUSZ, E. DALLWIGK AND E. BRINER. *Arch. Sci.*, **4**, 202–5 (*No.* 3, 1951) *In French.*

535.343–15

1643. Variation in the appearance of the fine structure of the infrared absorption spectrum observed with a slit of variable width. J. VINCENT-GEISSE. *C.R. Acad. Sci.* [*Paris*] **233**, 1179–81 (*Nov.* 12, 1951) *In French.*

The fine structure of a spectral band may be observed when the width of the spectrograph slit is greater than the distance apart of neighbouring lines provided the slit width is not a multiple of this distance. This is illustrated by results obtained with the fundamental vibration-rotation band of CO.

W. R. ANGUS

535.343.2

1644. The splitting of the Pr^{+++}-terms in trigonal single crystals of praseodymium-zinc-nitrate and praseodymium-magnesium-nitrate. K. H. HELLWEGE AND A. M. HELLWEGE. *Z. Phys.*, **130**, 549–60 (*No.* 4, 1951) *In German.*

At 20°K and 58°K the visible absorption spectrum of both salts is photographed with polarized light and a large dispersion. The three lowest components of H_4^3 and all components of $P_{0,1,2}^3$ and D_2^1 are accounted for by a crystal-field of symmetry C_3. The crystal quantum numbers μ of the components and the matrix elements of the crystal field are found. In the Zn-salt the field is stronger than in the Mg-salt.

C. TURNER

535.343.2

1645. Theoretical postulates for an explanation of the spectrum of Pr IV. E. TREFFTZ. *Z. Phys.*, **130**, 561–4 (*No.* 4, 1951) *In German.*

A theoretical justification of the assumptions in the paper by Hellwege (preceding abstract).

C. TURNER

535.343.2–15 : 548.5

1646. Infrared studies of mixed crystals: naphthalene in anthracene. G. C. PIMENTEL. *J. Chem. Phys.*, **19**, 1536–9 (*Dec.*, 1951).

Polarized infrared studies have been made using single crystals of dilute solid solutions of naphthalene in anthracene in the spectral region 755 to 830 cm^{-1}. The *ab* plane at normal incidence was studied with the plane of polarization either parallel or perpendicular to the *b* axis. The mole fraction of naphthalene was varied from 0·009 to 0·029. The contour of the naphthalene band at 787 cm^{-1} shows a dependence upon concentration, approaching the contour observed in pure naphthalene. There is an increasing dichroic splitting of the band which is attributed to space group coupling as the number of nearest identical neighbours increases. It is likely that the magnitude of this splitting in naphthalene is only about 5–10 cm^{-1} and that the crystal forces in naphthalene as well as in the mixed crystals of naphthalene in anthracene are sufficiently weak for the "oriented gas" model to be applicable. Using this model, the 787 cm^{-1} band of naphthalene is assigned as a single fundamental of either B_{1u} or B_{3u} class.

A.

535.343.2–15 : 548.7

1647. The influence of the surface of a molecular crystal on the excitation by light of intermolecular vibrations. V. M. AGRANOVICH AND A. S. DAVYDOV. *Zh. Eksper. Teor. Fiz.*, **21**, 677–83 (*No.* 6, 1951) *In Russian.*

Theoretical. The equation of motion of an infinite 1-dimensional chain is set up and leads to an expression for the limiting frequency at which the chain can be excited. The equation is then solved for a bounded chain of N links and gives a range of N limiting frequencies which are excited with amplitudes rapidly decreasing with distance from the limiting frequency of the infinite chain. This result explains the dependence of the i.r. spectrum of polymers on chain length. The treatment is extended to 3 dimensions and it is found that in the case of thin crystals with large absorption, a large part of the energy goes into the excitation of the band of frequencies near the limiting frequency for infinite thickness. That is, the surface can be said to cause a broadening of the band of frequencies excited.

Such a broadening has been observed by Prikhotko for naphthalene crystals 0·1 μ thick. A. L. MACKAY

535.343.3–31

1648. Observations on the apparent failure of Beer's law near the transmission point of a solvent. J. M. VANDENBELT, C. HENRICH AND S. L. BASH. *Science*, **114**, 576–7 (*Nov.* 30, 1951).

Ultra-violet absorption measurements of the primary bands of solutions of PhOH in 95% EtOH and in H_2O made over the conc. range 0·000702–0·0168M show that the wide range in the extinction coeff. and wavelength shift observed by Ungnade, Kerr and Youse [see Abstr. 6861 (1951)] is due primarily to experimental difficulties in the region of reduced solvent transmission. When these are eliminated, large variations indicating the failure of Beer's Law, are not apparent. J. GRANT

535.343.4 : 539.132

Pressure-induced absorption. *See Abstr.* 2018–19

535.343.4–15

1649. The infrared spectrum and the structure of gaseous nitrous acid. L. H. JONES, R. M. BADGER AND G. E. MOORE. *J. Chem. Phys.*, **19**, 1599–1605 (*Dec.*, 1951).

An investigation of the infrared spectrum of nitrous acid has shown that in the gaseous state this substance exists in two tautomeric species which are believed to be *trans*- and *cis*-forms. The *cis*-form is of higher energy by about 506 calories mole^{-1}. A complete vibrational analysis is given and the OH in plane bending frequencies are found to be 1 260 cm^{-1} and ~ 1 292 cm 1 292 cm^{-1}, and the out of plane frequencies 543 cm^{-1} and 637 cm^{-1} for the *trans*- and *cis*-molecules, respectively. From the rotational constants the O — N — O angle is estimated to be 118° for the *trans*-form and 114° for the *cis*-form, from which conclusions are drawn regarding the electronic structure of the molecule. The standard entropy of nitrous acid at 25° is calculated. A.

535.345–32

1650. Transmission of natural and synthetic mica in the ultra-violet. P. POPPER. Letter in *Nature* [*Lond.*] **168**, 1119–20 (*Dec.* 29, 1951).

Synthetic mica transmits further into the ultra-violet; thin films transmit "well below 2 000 Å" and are suitable as windows for vacuum devices.

G. F. LOTHIAN

535.347

1651. The infrared dichroism of diketopiperazine. T. SHIMANOUCHI, K. KURATANI AND S. MIZUSHIMA. *J. Chem. Phys.*, **19**, 1479–80 (*Dec.*, 1951).

The absorption of polarized infrared radiations by diketopiperazine crystal has been measured in the wavelength region from 2·8 to 15 μ. From the observed infrared dichroism the assignment of the absorption bands has been made. A.

535.37

1652. Free electrons, traps and glow in crystal phosphors. M. E. WISE. *Physica*, **17**, 1011–32 (*Nov.–Dec.*, 1951).

The well known monomolecular and bimolecular theories of afterglow and thermal glow are summarized. Observed results on phosphors of ZnS type are discussed, particularly the phosphors with long afterglow in which the intensity-time laws are hyperbolic. These have been explained by many workers by a monomolecular theory with a distribution of depths of electron traps. It is shown that certain mathematical approximations that must be used in relating the theory to observations of afterglow and thermal glow are not accurate enough and a new and simple law is given that describes the same observations mathematically. A new physical theory for the free and trapped electrons is outlined, and this is discussed in relation to F and F' centres in alkali halides and to an unsolved problem of semiconductor theory. A.

535.371

1653. Fluorescence and absorption of crystalline stilbene. P. PESTEIL. *C.R. Acad. Sci.* [*Paris*] **233**, 1356 (*Nov.* 26, 1951) *In French.*

Correction to Abstr. 9390 (1951) and Abstr. 903 (1952). The fluorescence vibration is in the direction of the long axis L. The weak absorption bands are due to vibrations parallel to L, and the strong ones due to transitions parallel to the short axis M.

C. TURNER

535.371

1654. Barium titanium phosphate: a new phosphor. S. T. HENDERSON AND P. W. RANBY. *J. Electrochem. Soc.*, **98**, 479–82 (*Dec.*, 1951).

The preparation is described of barium pyrophosphate containing about 30 molar % of titanium dioxide but no other addition. The mechanism of its formation has been examined by differential thermal analysis and by X-ray diffraction, but the structure has not yet been fully elucidated. Its luminescent properties are similar in many respects to those of magnesium tungstate, for which it is a useful substitute in fluorescent lamps. It has short afterglow, high efficiency, good maintenance in the mercury discharge, and an emission band extending through the whole visible spectrum with a peak at 4 835 Å. A.

535.371

1655. On the measurement of "Daylight Fluorescent" materials. J. E. TYLER AND F. P. CALLAHAN, JR. *J. Opt. Soc. Amer.*, **41**, 997–1001 (*Dec.*, 1951).

A method is described for analysing the light remitted from certain Daylight Fluorescent Colours into its reflected and fluoresced components. The evaluation in both cases is on any energy basis (expressed on a percentage scale) as a function of the wavelength of the exciting radiation when the energy content of the exciting beam is held constant. A.

535.371 : 537.311.33

New views on oxidic semiconductors and zinc sulphide phosphors. *See Abstr.* 1792

535.371 : 539.11

1656. Radiationless electron transitions in crystals. F. STÖCKMANN. *Z. Phys.*, **130**, 477–9 (*No.* 4, 1951) *In German.*

A theoretical consideration of the probability of radiationless electron transitions for electrons captured in the Coulomb field of a lattice defect. The theory offers possible application to the mechanism

of such transitions in phosphors with and without "killer" centres such as Fe, Ni and Co.

G. F. J. GARLICK

535.371 : 541.65

1657. A new theory upon the fluorescence and chemical constitution of organic compounds. R. ODA AND Z. YOSHIDA. *Mem. Fac. Engng Kyoto Univ.*, **13**, 108–22 (*July*, 1951).

Two main conditions are postulated for the occurrence of fluorescence in organic compounds, namely, the presence of a conjugated ring system and change of electron density in the double bond atom due to resonance. The effect of substituent groups on fluorescence is considered, in particular the different cases of substituents which increase the electron density and those which decrease it in the ring system. Large numbers of compounds of different types are cited as examples supporting the above theory.

G. F. J. GARLICK

535.372

1658. The temperature dependence of the fluorescence spectrum of anthracene on excitation by light and cathode rays. K. HENGST. *Z. Naturforsch.*, **6a**, 540–3 (*Oct.*, 1951) *In German.*

Diagrams are given of the spectra at 170°, 20° and — 180°C for excitation by long ultra-violet and by 40-kV electrons. In the latter case the phosphor is separated from the evacuated c.r. tube by an Al foil 7 μ thick. For both types of excitation decrease of temp. causes the band with a peak at 4 240 Å to increase at the expense of the band at 4 420 Å. For a 1% solid solution of anthracene in naphthalene the higher frequency band is much the stronger and there is little change at — 180°C; also solutions of anthracene in benzene show similar spectra by c.r. excitation at room temperature. In commercial quality anthracene the temp. behaviour of fluorescence is the same as in the pure material, except that the extra bands due to impurities behave like those of anthracene in solid solution. S. T. HENDERSON

535.372

1659. The spectrograms of some ultraviolet scintillators. H. O. ALBRECHT AND C. E. MANDEVILLE. Note in *Rev. Sci. Instrum.*, **22**, 855–6 (*Nov.*, 1951).

The ultra violet luminescence spectra of CaF_2, NaCl–Ag, NaBr–Ag, Al_2O_3, Corning 9 741 glass and stilbene are measured using Eastman 103*a*–0 plates.

G. F. J. GARLICK

535.372

1660. Theoretical spectra of luminescent solids. F. E. WILLIAMS AND M. H. HEBB. *Phys. Rev.*, **84**, 1181–3 (*Dec.* 15, 1951).

From the potential energy curves for the ground and excited states of the Tl activator in KCl, the absorption spectrum of this phosphor is calculated by direct evaluation of the matrix elements for electronic transitions between the individual vibrational levels of the initial and final states. Harmonic oscillator wave functions in the initial state and wave functions for a linear potential in the final state are used. The results verify the classical and semiclassical spectra previously reported, and provide a new insight into the application of the Franck–Condon principle to solid-state luminescence.

A.

535.372

1661. Fluorescence lines in the spectrum of light scattered by calcite. S. BHAGAVANTAM AND P. G. PURANIK. Letter in *Nature* [*Lond.*] **169**, 37 (*Jan.* 5, 1952).

A study of the scattered spectrum of calcites shows three sharp lines at 2 838, 2 883 and 2 905 Å which appear to be fluorescence lines as distinct from the Raman lines.

G. F. J. GARLICK

535.375.5

1662. Analysis of the Raman spectra of sodium and potassium tartrates. V. M. PADMANABHAN. *Proc. Indian Acad. Sci. A*, **34**, 155–60 (*Sept.*, 1951).

535.375.5 : 548.7

1663. The first order Raman effect in crystals, particularly in diamond. O. THEIMER. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1012–30 (*Nov.*, 1951).

The theory of the first order Raman effect in crystals is presented in a form which takes into account the finiteness of the wavelength of the incident radiation. The theory is applied to calculate the relative intensities of the first order Raman line and of the Brillouin components of diamond, which are interpreted as the Stokes and anti-Stokes Raman lines produced by those elastic vibrations, whose wave vector Q fulfils the condition $Q = Q'' - Q'$. (Q' and Q'' are the wave vectors of the incident and scattered radiation.) The calculated intensities are in good agreement with experiments of Krishnan. A formula derived by Leontowitsch and Mandelstamm is discussed and is shown to be inadequate to calculate the intensities of the Brillouin components.

A.

535.375.54

1664. Raman spectrum in $CaSO_4 . 2H_2O$ crystals. M. SANTANGELO. *Ric. Sci.*, **21**, 1391–4 (*Aug.*, 1951) *In Italian.*

The first results of a research on the Raman effect in gypsum. Some bands of low frequency, attributed to reticular vibrations, and a band at 1 170 cm^{-1} are emphasized.

A.

535.375.54

1665. The Raman spectrum of $MnCl_2 . 4H_2O$ in the mono-crystalline state. A. GALY. *C.R. Acad. Sci.* [*Paris*] **233**, 1181–3 (*Nov.* 12, 1951) *In French.*

Raman lines observed in the frequency range 44–3 650 cm^{-1} using polarized light at ordinary temps. are recorded and interpreted.

W. R. ANGUS

535.375.54

1666. The vibration spectrum of rutile. F. MATOSSI. *J. Chem. Phys.*, **19**, 1543–7 (*Dec.*, 1951).

Raman effect data for rutile are evaluated for the force constants. It is shown that quasi-molecules TiO_2 are formed with strong Ti–O bonds although every Ti atom is surrounded by 6 O atoms in about equal distances. The main force constants are (in 10^5 dynes/cm) 1·7 for the Ti–O bond of the quasi-molecules, 0·06 for the other Ti–O bonds, 0·2 for O–O bonds. The spectrum can be interpreted as that of coupled modified TiO_2 molecules whose effective bond strength is a combination of the actual bond strengths.

A.

535.376

1667. On the fluorescence produced by α-particles in solutions. M. AGENO AND R. QUERZOLI. *Atti Accad. Naz. Lincei* (*R.C.Cl. Sci. Fis. Mat. Nat.*) **11,** 65–7 (*Nov.*, 1951) *In Italian.*

Photographs under various conditions of the fluorescence imparted to solutions in xylene by approximately 10 millicuries of Po deposited on a Ni disk (dia. 5 mm) immersed in the solution, indicate that the fluorescence arises from the energy imparted to the molecules of the solution during the first few cm of the passage of the α-particles from the Po, and that beyond the area of luminosity approx. 1 cm around the disk the fluorescence is absorbed by the solution. Diffusion of the fluorescent liquid molecules or of the Po are excluded by the experiments as the source of the fluorescence. J. GRANT

535.376

1668. Response of some scintillation crystals to charged particles. C. J. TAYLOR, W. K. JENTSCHKE, M. E. REMLEY, F. S. EBY AND P. G. KRUGER. *Phys. Rev.*, **84,** 1034–43 (*Dec.* 1, 1951).

The dependence of the response of anthracene, stilbene and NaI crystals in a scintillation detector on the type and energy of charged particles incident on the crystal has been investigated. Electrons with energies from 500 eV to 624 keV, deuterons and molecular hydrogen ions with energies of 1 to 11 MeV, protons of 1 to 5 MeV, and alpha-particles of 4 to 21 MeV were employed. With the exception of protons and deuterons in NaI, which gave a linear response over the entire energy region investigated, plots of pulse height *v.* energy for heavy particles gave a nonlinear relation for low energies tending toward linearity with increasing particle energy. Electrons in anthracene and stilbene show a nonlinear response below 100 keV, while the NaI curve is linear above 1 000 eV. The response of anthracene, whose behaviour may be typical of organic crystals, has been compared with different ionizing radiations by considering the variation of the specific energy loss. Both electrons and heavy particles seem to show regions of linear response which start at quite different values of dE/dx. As the specific energy loss increases the response becomes nonlinear, with the ultimate saturation of the specific fluorescence for large values of dE/dx. A.

535.376

1669. Scintillations in thallium-activated CaI_2 and CsI. W. VAN SCIVER AND R. HOFSTADTER. Letter in *Phys. Rev.*, **84,** 1062–3 (*Dec.* 1, 1951).

Under excitation by Co^{60} γ-rays, CaI_2–Tl (1%) has an efficiency equal to that of a NaI–Tl crystal with a decay time of 1·1 μsec. CsI–Tl has a similar decay time to that of CaI_2–Tl but a relative efficiency of only 30%. G. F. J. GARLICK

535.376

1670. Energy response of NaI(Tl) crystals to alpha particles of less than 10 MeV. R. H. LOVBERG. Letter in *Phys. Rev.*, **84,** 852 (*Nov.* 15, 1951).

The exact form of the non-linear relation between output pulse height and particle energy is investigated for NaI–Tl crystals over the α-particle energy range 1–10 MeV. G. F. J. GARLICK

535.39 : 535.417

1671. An interferometric method for the determination of the absorption coefficients of metals, with results for silver and aluminum. L. G. SCHULZ. *J. Opt. Soc. Amer.*, **41,** 1047–51 (*Dec.*, 1951).

An interferometric method is described for determining the absorption coefficients of metals from the change in phase accompanying the reflection of light at normal incidence. The reflecting layers in an interference filter are made of the metal being studied. From the optical thickness of the dielectric between the reflecting layers and the wavelength of the light transmitted, the phase change can be calculated. A monochromatic light source is not required, and with photographic methods it is possible to extend the measurements beyond the visible region. Results are given for Ag and Al in the wavelength range of 3 600 Å to 8 100 Å. For Al the index of refraction is also given for this range. It was found that the dispersion of evaporated films of MgF_2 increased with thickness. An interferometric method is described for studying the rate of growth of corrosion layers on films which have been exposed to air. Ag films could be exposed without any apparent corrosion. The oxide layer on Al films reached a maximum thickness of about 45 Å. A.

535.417

1672. The investigation of thin absorbing films with the help of the absolute phase. H. SCHOPPER. *Z. Phys.*, **130,** 565–84 (*No.* 5, 1951) *In German.*

A discussion of absorbing films whose thickness is small compared with the wavelength of light is given, based on earlier methods. It is possible to derive unambiguously the optical thickness. By comparing the mass thickness a packing factor is derived. The anomalies in the optical constants remain unexplained if it be assumed as formerly that the film is a volume distribution of spherical particles. On the other hand theory and experiment are in agreement if the structure is taken to be that of a surface distribution of rotation ellipsoids. S. TOLANSKY

535.417

1673. A simplified shearing interferometer. R. L. DREW. *Proc. Phys. Soc.* [*Lond.*] *B,* **64,** 1005–12 (*Nov.*, 1951).

A simple new design of interferometer based on the wave-front shearing principle is described and illustrations given of its application to the solution of a variety of "through-type" and autostigmatic testing problems. A.

535.417 : 533.5

1674. Multiple-beam interferometry and the influence of vacuum technique. S. TOLANSKY. *Vacuum,* **1,** 75–91 (*April*, 1951).

A discussion of the influence of specific vacuum techniques on the preparation of the highly reflecting thin films used for multiple-beam interferometry. It is shown that the absorption of the film plays an important part particularly with reflection type fringes and that it should be as low as possible. The factors affecting absorption are surveyed. It is concluded that good films are produced by evaporation of silver using a mercury diffusion pumping system with an efficient liquid air trap. Oil (or silicone)

diffusion pumping systems without traps can produce films of high reflectivity but the absorptions of such films are greater than those using the mercury pump with trap. Cleaning techniques and empiric methods for assessing the films formed are described in detail. Silver is the best metal so far available for multiple-beam interferometry. A.

535.417 : 535.345.6

1675. Transmission interference filters of metallic thin films. H. YOSHINAGA AND T. IWASAKI. *Techn. Rep. Osaka Univ.*, **1**, 157–66 (*Oct.*, 1951).

These were made by the vacuum evaporation method. They show excellent monochromatic characteristics conforming well to the theoretical design, and can be modified to various types having many applications.

535.417 : 535.345.6

1676. A narrow passband polarization interference filter for hydrogen alpha. B. H. BILLINGS, S. SAGE AND W. DRAISIN. *Rev. Sci. Instrum.*, **22**, 1009–17 (*Dec.*, 1951).

Discusses the construction and testing of a Lyot–Öhman type polarization interference filter. This filter has a bandwidth of approximately 1 Å peaked at H alpha. Previous filters have been fabricated, mainly of quartz. For a 1 Å passband filter a quartz thickness of approximately 24 cm would be needed for the thickest plate. This filter has been constructed using ammonium dihydrogen phosphate. Because the birefringence of this material is much higher than that of quartz, the tolerances associated with its construction are severe. By the use of mica corrector plates or optical shims, the tolerances can be made less critical. The final filter is equipped with a Senarmont compensator at each end so that the passband can be adjusted over a range of about 3 Å. A.

535.417 : 535.81

1677. An interferential lens centring lathe and edging machine. G. A. HARLE. *J. Sci. Instrum.*, **28**, 365–8 (*Dec.*, 1951).

The paper sets out the principles of an interference method for the centring of optical systems with one and two surfaces. A description is given of the design and performance of an interferential transmission centring lathe and edging machine developed for use in the construction and examination of symmetrical and asymmetrical lenses, together with a reflection type centring apparatus for use with mirrors, and lenses of special quality. A.

535.42

1678. An experimental demonstration of the "minimum light" condition. H. MOSER AND J. WITTMANN. *Z. Phys.*, **131**, 48–50 (*No.* 1, 1951) *In German.*

The minimum light condition requires a 180° phase difference between the two halves of the beam giving a diffraction image of a slit. This difference arises in a polarized beam by reflection from a partially silvered glass surface and is shown to be nearly independent of wavelength. White light may then be used to give sharp fringes. R. W. FISH

535.42

1679. The validity of Babinet's theorem. H. BOERSCH. *Z. Phys.*, **131**, 78–81 (*No.* 1, 1951) *In German.*

This theorem states that the Fraunhofer diffraction patterns due to complementary screens are similar. This is shown in general to be invalid, although under certain conditions it may be a good approximation. R. W. FISH

535.42

1680. An elementary phenomenon of light diffraction. W. KOSSEL AND K. STROHMAIER. *Z. Naturforsch.*, **6a**, 504–8 (*Sept.*, 1951) *In German.*

The different methods of considering the diffraction of light are recalled, and it is shown that the diffraction of light at a transparent screen has a closer similarity to the diffraction of X-rays and material waves by crystal gratings, than the more usual case of light diffraction at an opaque screen. Experiments on the diffraction at the boundary of a transparent screen are described and photometer curves of the intensity variation for a series of phase differences are given. A method of indicating the position of the geometric shadow of the boundary is described. R. W. FISH

535.42

1681. Recording of concentration gradients by the minimum ray method. O. ARMBRUSTER, W. KOSSEL AND K. STROHMAIER. *Z. Naturforsch.*, **6a**, 510–11 (*Sept.*, 1951) *In German.*

A brief description of 4 methods of obtaining curves for the evaluation of concentration gradients during electrophoresis or sedimentation in an ultra-centrifuge, the minimum ray method [H. Wolter: Abstr. 232 (1951)] being described in more detail. The mutual weakening of contrasts, occurring when 2 lines, e.g. the concentration and the reference line, are photographed together, can be obviated by placing the phase edge in the centre of a relatively wide slit. Phase edge can be, e.g. an Al_2O_3 film or any transparent material, e.g. collodium films on glass. F. LACHMAN

535.42

1682. Experimental test of Fresnel diffraction theory with photomultiplier tube. S. F. HAYES. Note in *Amer. J. Phys.*, **20**, 53–4 (*Jan.*, 1952).

The intensity distribution in the diffraction pattern of a slit is found by means of a photo-multiplier tube. The experimental values agree well with the values predicted by the Fresnel theory, both in lateral spacing of the maxima and minima and their relative heights. Practical details of the apparatus are given. R. W. FISH

535.42 : 534.321.9

1683. Diffraction of light by two ultrasonic waves. R. R. AGGARWAL AND S. PARTHASARATHY. *Acustica*, **1**, 74–8 (*No.* 2, 1951).

An explanation is offered on the basis of existing theories for the diffraction of light by ultrasonic waves, for the inequalities in intensity recorded in the photographs obtained by Bergmann, when diffraction spectra are obtained by exciting a quartz-crystal simultaneously at two frequencies; these inequalities being in the side-bands of the first-order spectrum excited by h.f. sound waves. A.

535.42

1684. Interaction of matter and radiation in the region of optical resonance. S. KICHENASSAMY. *J. Phys. Radium*, **12**, 863–7 (*Nov.*, 1951) *In French.*

Proposes a new interpretation of the A^2 term in the non-relativistic Hamiltonian for the interaction of an

electron and radiation; applied to the scattering of light in the region of atomic resonance it explains the experimental results of Lennuier [Abstr. 2522 (1947)].

P. M. DAVIDSON

535.43 : 541.18

1685. The contribution of light scattering to the extinction of proteins. R. Lontie, M. Dessent and K. Heirwegh. *Meded. K. Vlaamse Acad. Wetensch. Belg.*, **13**, 14 *pp.* (*No.* 1, 1951).

Scattering and extinction coefficients are determined at 2 780 Å, 3 460 Å and 5 460 Å at various *p*H for *Helix pomatia* haemocyanin. The specific scattering power is measured at 5 460 Å and 5 780 Å; this decreases with lower concentration if determined under 90°, but the scattering coefficient remains constant.

A. J. TAYLOR

535.43 : 548.7

1686. The scattering of light in crystals and the nature of their vibration spectra. C. V. Raman. *Proc. Indian Acad. Sci. A*, **34**, 61–71 (*Aug.*, 1951).

The facts of light-scattering in crystals are reviewed and the nature of the atomic movements and the character of their vibration spectra in the different frequency regions are deduced therefrom. Whereas the movements based on the translations of the lattice cells result in elastic wave motions in the solid with a continuous frequency spectrum, the modes based on their internal vibrations are localized and have monochromatic frequencies analogous to those of polyatomic molecules. The total degrees of atomic freedom are shared between the latter and the former in the ratio $(24p - 3) : 3$. The frequency shifts ordinarily observed in light-scattering arise from the group of $(3p - 3)$ modes in which the phase of the vibration is the same in adjacent cells of the lattice. But these as well as the $21p$ additional modes in which the phase alternates along the axes can give rise to shifts which are overtones and summations of their fundamental frequencies. The localization of the internal vibrations permits of these overtones and summations appearing as frequency shifts with observable intensity. On the other hand, the continuous spectrum of elastic vibrations is completely inactive in light-scattering, apart from the particular case of a coherent reflection of the light waves by the elastic wave pattern.

A.

535.434

1687. Scattering of light in water kept in contact with metals. A. George. Letter in *Curr. Sci.*, **20**, 201–2 (*Aug.*, 1951).

535.514

1688. Some aspects of the development of sheet polarizers. E. H. Land. *J. Opt. Soc. Amer.*, **41**, 957–63 (*Dec.*, 1951).

Reviews the 25 years of activity, by the author and his co-workers, in the development of synthetic sheet polarizers. The early work during the 19th century and the various stages of the modern development in the author's laboratory are described. A description is given of the nature and the optical properties of the currently-available sheet polarizers of the Polaroid *J*, *H*, *K* and *L* types, and of the quantitative methods used in characterizing them. The reasons are given for developing special polarizers for each of a variety of applications such as optical instruments, vectographs and headlights.

A.

535.514

1689. A monochromatic depolarizer. B. H. Billings. *J. Opt. Soc. Amer.*, **41**, 966–75 (*Dec.*, 1951).

This depolarizer consists of two variable wave plates whose axes are separated by an angle of 45°. The retardation of the first wave plate varies from zero to 2π. The second wave plate varies from zero to 4π. This variation is made to occur in a time which is short compared to the time constant of the apparatus in which the depolarizer is used. Typical components are *Z* cut plates of ammonium–dihydrogen–phosphate. The retardation of these plates can be made to vary by applying an electric field along the optic axis. A discussion is also given of the Lyot depolarizer which is effective for light which covers a wide wavelength range. Tolerances are derived for the behaviour of the Lyot depolarizer and experimental measurements are shown of its behaviour.

A.

535.514

1690. On the properties of polarization elements as used in optical instruments. I. Fundamental considerations. C. D. West and R. C. Jones. *J. Opt. Soc. Amer.*, **41**, 976–82 (*Dec.*, 1951).

Discusses some of the general considerations relating to the use in optical instruments of polarization elements, with particular emphasis being given to partial polarizers of the dichroic type. A functional classification is provided for optical instruments which employ polarized light. Also provided is a functional classification for polarization elements, which classification involves four categories: polarizers, phase shifters, polarizing beam splitters and depolarizers. The various methods of modulating light are discussed. A qualitative description of partial dichroic polarizers is included, and this is followed by the derivation of some of the basic mathematical relations which hold among the parameters which can be used to describe quantitatively the properties of partial dichroic polarizers.

A.

535.514

1691. On the properties of polarization elements as used in optical instruments. II. Sinusoidal modulators. R. C. Jones and C. D. West. *J. Opt. Soc. Amer.*, **41**, 982–6 (*Dec.*, 1951).

Begins with a general formulation of the problem of the optimum polarizer. It is suggested that the problem must be investigated by studying separately each of the classes of applications of polarizers, and the rest of the paper is addressed to the derivation of the optimum polarizer for use in a *sinusoidal modulator*, defined as two polarizers rotating at substantially constant relative angular velocity. The optimum polarizer is defined as the one which yields a *sinusoidal modulator* whose operation upon a given beam of light yields a maximum signal-to-noise ratio in the transmitted light. An expression is derived for said signal-to-noise ratio, and from this a specific combination of polarizer parameters is obtained which is to be maximized. Explicit expressions are obtained for the values of the various parameters which provide the optimum polarizer; the results are exhibited graphically.

A.

535.514

1692. Thallium bromide-iodide (KRS-5) as an infrared polarizer. R. T. LAGEMANN AND T. G. MILLER. Letter in *J. Opt. Soc. Amer.*, **41**, 1063–4 (*Dec.*, 1951).

Two KRS-5 plates of thickness 4 mm and four of thickness 1 mm were used in a pile of various combinations as a polarizer. Comparison with a pile containing an equal number of silver chloride plates showed that KRS-5 gave a slightly inferior transmission but a better percentage polarization. Experiments were made in the wavelength range 1–15 microns, but KRS-5 may be used up to 40 microns; its efficiency is not impaired by continuous use at short wavelengths. H. G. JERRARD

535.52 : 548.0

Dipole and quadrupole radiation fields in non-cubic crystals. *See Abstr.* 2229

535.54 : 548.0

1693. Thermo-optic behaviour of silicon carbide. A. K. RAMDAS. *Proc. Indian Acad. Sci. A*, **34**, 136–40 (*Aug.*, 1951).

The dispersion and birefringence of carborundum are well represented by the formulae

$$\omega^2 = 1 + k_1\lambda^2/(\lambda^2 - \lambda_1^2) + k_2\lambda^2/(\lambda^2 - \lambda_2^2)$$
$$\varepsilon^2 = 1 + k_3\lambda^2/(\lambda^2 - \lambda_1^2) + k_4\lambda^2/(\lambda^2 - \lambda_2^2)$$

where $\lambda_1 = 155$ mμ, $\lambda_2 = 175$ mμ, $k_1 = 3{\cdot}657$, $k_2 = 1{\cdot}898$, $k_3 = 1{\cdot}626$, $k_4 = 4{\cdot}11$. The theory of thermo-optic behaviour of solids [Abstr. 2479 (1949)] when applied to the case of carborundum explains the observed positive temperature coefficient of both the indices.

535.55

1694. Photoelastic constants of sodium chlorate from ultrasonic diffraction. K. VEDAM AND G. N. RAMACHANDRAN. *Proc. Indian Acad. Sci. A*, **34**, 240–4 (*Oct.*, 1951).

Details are given of the theory and technique of measuring photoelastic constants in optically active cubic crystals from ultrasonic diffraction of light. The results thus obtained, in conjunction with the measurements of relative path retardation produced by stressing the crystal, enable one to obtain all the four constants independently. A.

535.551 : 548.0

1695. Photoelastic properties of barite. K. VEDAM. *Proc. Indian Acad. Sci. A*, **34**, 161–72 (*Sept.*, 1951).

All the 12 elasto-optic constants of barite have been determined and the values obtained for λ5893 are

$p_{11} = 0{\cdot}21$ $p_{44} = 0{\cdot}002$ $p_{12} = 0{\cdot}25$ $p_{23} = 0{\cdot}19$
$p_{22} = 0{\cdot}24$ $p_{55} = -0{\cdot}012$ $p_{13} = 0{\cdot}16$ $p_{31} = 0{\cdot}275$
$p_{33} = 0{\cdot}31$ $p_{66} = 0{\cdot}037$ $p_{21} = 0{\cdot}34$ $p_{32} = 0{\cdot}22$

The behaviour of the optical properties of barite on uniform compression on all sides is discussed. The true temperature coefficients of the three principal refractive indices have also been calculated. A.

535.561 : 548.0

1696. The theory of optical activity of crystals. III. Calculation of the rotatory power of β-quartz. G. N. RAMACHANDRAN. *Proc. Indian Acad. Sci. A*, **34**, 127–35 (*Aug.*, 1951).

Using the general theory of Part I [*Proc. Indian Acad. Sci. A*, **33**, 217, 309 (1951)] the rotatory powers of β-quartz along and perpendicular to the axis are calculated to be 236° and 115°. These agree well with the value 252° observed for the former and the value 0·50 observed for the ratio of the two in α-quartz. A.

535.65

1697. On the definition of standard illuminant A. W. DE GROOT. *Physica*, **17**, 920–2 (*Oct.*, 1951).

Some remarks on the definition of standard illuminant A, with special reference to the (provisional) CIE recommendation, as formulated during the CIE meeting, Stockholm, 1951. A.

535.65

1698. Calculation of color differences from visual sensitivity ellipsoids. H. R. DAVIDSON. *J. Opt. Soc. Amer.*, **41**, 1052–6 (*Dec.*, 1951).

All colour difference equations are based, either explicitly or implicitly, on the measurement of the distance between the two colours when plotted in a visually uniform colour space. The accuracy of these equations depends upon the approximations assumed in their derivation and the uniformity of the colour space chosen. Judd's Uniform Chromaticity space, Adam's Chromatic Value space, the Mansell space and others have been used as the basis of colour difference equations. Instead of explicitly transforming the ICI space into a visually uniform space, its known distortions can be compensated by means of the MacAdam ellipsoids. Colour differences may be calculated very simply by a graphical method, assuming any point on the ellipsoids to represent a unit colour difference from the centre of the ellipsoid. Calculations of this sort have been applied to the Balinkin data on tiles and to data more recently obtained on textile dyeings. Colour differences calculated by this method correlate with visually estimated colour differences as closely as do differences calculated by the best of the equations based upon uniform colour spaces. This appears to be further confirmation of the validity of the MacAdam ellipsoids and of their usefulness in specification of colour tolerances. A.

535.89 : 778.37

1699. A repetitive spark source for shadow and Schlieren photography. G. K. ADAMS. *J. Sci. Instrum.*, **28**, 379–84 (*Dec.*, 1951).

Two methods of producing sparks of high brightness and short duration at high repetition frequencies are described. The circuits used are simplified versions of standard radar techniques and moderate voltages (5–10 kV), and standard components are used. The first method gives a limited number of discharges (four to eight) at individually determined time intervals of ten microseconds or greater, with an error of less than one microsecond, and is intended for the production of superimposed photographs on a stationary film. The second method, used with a rotating drum or mirror camera, gives a greater number of light pulses at preset repetition frequencies up to 10 000 per sec. The energy of each spark is of the order of 1 joule, and the effective photographic duration less than 1 μsec. Adequate negative densities are obtained on process type emulsions at distances not greater than 1 metre. The elementary

principles underlying the methods are briefly discussed, and suggestions are made for increasing the flash energy and repetition frequency. A.

HEAT 536

536.2

1700. A new method of determining thermal diffusivity of solids at various temperatures. D. Rosenthal and A. Ambrosio. *Trans Amer. Soc. Mech. Engrs*, **73**, 971–4 (*Oct.*, 1951).

The method under review affords a rapid means of determining thermal diffusivity and is especially suitable to measurements at high temperatures. The theory of moving heat sources is the basis for this method. When the theory is applied to the case of unidimensional heat flow in a long prismatic bar, being heated by a moving point heat source, an equation which permits the computation of thermal diffusivity at each temperature is obtained. The experimental technique involves the measurement of the temperature-time history at a single point of the bar, using two different heat-source velocities. A.

536.2.08

1701. A radial heat flow apparatus for the determination of thermal conductivity. A. C. Burr. *Canad. J. Techn.*, **29**, 451–7 (*Nov.*, 1951).

The apparatus was designed for routine measurement in the range 0·001 to 0·1 c.g.s. units but could be modified easily for measurements on metals or on refractory materials. Results of determinations on this material between 400°C and 700°C are shown, together with results for a typical sample of petroleum coke electrode carbon. The accuracy is estimated to be about ± 5%. A.

536.212.2 : 536.48

1702. Thermal conductivities of pure metals at low temperatures. I. Aluminium. F. A. Andrews, R. T. Webber and D. A. Spohr. *Phys. Rev.*, **84**, 994–6 (*Dec.* 1, 1951).

The thermal conductivities of 3 specimens of highly pure Al have been measured in the temperature range 2 to 20°K. All specimens showed maximum conductivities in the temperature range 14 to 17°K. The measured values are compared with the theory of Sondheimer. The number of effective conduction electrons per atom is found to be 0·061. A.

536.212.2 : 538.69

1703. The thermal conductivity of cadmium in a magnetic field at low temperatures. K. Mendelssohn and H. M. Rosenberg. Letter in *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1057–8 (*Nov.*, 1951).

A transverse field of 3 800 gauss increased thermal resistance 5 times at 4·4°K and over 7 times at 2·2°K. A longitudinal field had much less effect. Au, Mo, Rl, U did not show this effect.

536.248

1704. Steam heat transfer to small drops of water. S. Weinberg. *Brit. J. Appl. Phys*, **2**, 363–6 (*Dec.*, 1951).

In cases of drop heat transfer in which a saturated atmosphere condenses into the liquid of the drop, a point is reached when the drop is at the atmospheric temperature. If formal treatment is given to the heat transfer up to that time, the end temperature difference being zero, the conception of logarithmic mean temperature difference cannot be used and an arbitrary choice which may give misleading results must be made. That heat transfer does continue with this apparent zero difference is obvious and therefore a potential difference must exist which is shown to be expressible as an equivalent temperature difference. A.

536.25

1705. Heat transfer by natural convection in laminar boundary layer on vertical flat wall. S. Sugawara and I. Michiyoshi. *Mem. Fac. Engng Kyoto Univ.*, **13**, 149–61 (*Oct.*, 1951).

This problem has already been theoretically studied by Pohlhausen, but his method is very troublesome and since he uses Schmidt and Beckmann's experimental results for air, Pohlhausen's solution is not applicable to other kinds of fluids except air. The problem has been analysed for gas and liquid by means of three different approximate methods and compared. A.

536.25

1706. Free convection heat transfer from electrically heated wires. E. A. Farber. *J. Appl. Phys.*, **22**, 1437–8 (*Dec.*, 1951).

Discusses the heat transfer from Cu and Fe wires to distilled water between freezing and boiling, to water boiling at atmospheric conditions and to air at room temperature. The wire surface temperatures needed for the heat transfer determination are calculated from the theoretical temperature distribution in the wire. The experimental results show maximum heat transfer rates of about 2 200 000 B.Th.U./hr, ft² near freezing and 450 000 B.Th.U./hr, ft² near boiling. For boiling water, as the temperature difference between the wire surface and water is increased, the heat transfer coefficient first increases reaching a maximum, then decreases reaching a minimum and increases again (because of radiation) until the wire fails by melting. For Cu the maximum film coefficient of 9 100 B.Th.U./hr, ft², °F is observed at 49 degrees temperature difference and the minimum of 136 B.Th.U./hr, ft², °F at a temperature difference of 690 degrees F. Corresponding values for Fe are 12 300 B.Th.U./hr, ft², °F at a 33 degree temperature difference and 142 B.Th.U./hr, ft², °F at a 620 degree difference. When air at room temperature surrounds the wire the heat transfer coefficient for Cu with an oxide film varies from 0 to 30 and for Fe from 0 to 26 B.Th.U./hr, ft², °F as the surface temperature of the wires is raised until failure occurs. A.

536.255

1707. Convection currents in porous media. IV. Remarks on the theory. F. T. Rogers, Jr, L. E. Schilberg and H. L. Morrison. *J. Appl. Phys.*, **22**, 1476–9 (*Dec.*, 1951).

Differential equations for critical stability of a fluid in a porous medium and heated from below are solved by an approximate method not hitherto used. A single formula is obtained for the thermal environment at critical stability, apparently valid over a wide

range of conditions, which allows for temperature dependence of viscosity and non-linear temperature distributions. New experiments are reported in which initial convection has been detected by visual, thermal and radioactive-trace means. Experimental mean thermal gradients for critical stability deviated from values predicted by the new solution of theory by the following average amounts: visual, 150%; thermal, 32%; radioisotopic, 11%. A.

536.255 : 532.5

Detection of small convective fluid flows by radioactive traces. *See Abstr.* 1502

536.413 : 536.631

1708. Thermal expansion and specific heat of tungsten oxide at high temperatures. S. SAWADA, R. ANDO AND S. NOMURA. Letter in *Phys. Rev.*, **84,** 1054 (*Dec.* 1, 1951).

The temperature variation of the expansion coefficient indicates a slight maximum at 330°C and a very pronounced sharp minimum at 755°C. The specific heat curve exhibits a λ-point near 730°C. The high temperature anomalies are a result of the disappearance of the spontaneous ferroelectric polarization. The low temperature anomaly in the expansion curve is not fully understood; the electrical resistance also exhibits an anomaly near 330°C.

E. P. WOHLFARTH

536.413 : 539.155.4 : 548.736.1

Precision determination of lattice parameter, coefficient of thermal expansion and atomic weight of carbon in diamond. *See Abstr.* 2262

536.413 : 548.0

1709. Thermal expansion of crystals. VIII. Galena and pyrite. S. S. SHARMA. *Proc. Indian Acad. Sci. A,* **34,** 72–6 (*Aug.*, 1951).

For Pt IV, see Abstr. 3189 (1951). The coefficients of linear expansion in the range (0–400)°C are respectively given by $\alpha_t = 0{\cdot}0_41843 + 0{\cdot}0_86071\,t + 0{\cdot}0_{10}1176\,t^2$ and $\alpha_t = 0{\cdot}0_58401 + 0{\cdot}0_71125\,t + 0{\cdot}0_{11}9168\,t^2$. Grüneisen's constant has been evaluated and is found to vary with temperature. A.

536.422/.423

1710. Theory of the velocity of evaporation. O. KNACKE I. N. STRANSKI AND G. WOLFF. *Z. phys. Chem.* **198,** 157–85 (*No.* 1–4, 1951) *In German.*

Equations for the velocity of evaporation are derived, using models of a liquid and a crystal. The following three cases are considered for the evaporation of a crystal: (1) the diffusion of the evaporating molecules on the crystal surface occurs both along, and normally to, the ledge adjacent to the semi-crystalline position; (2) the diffusion occurs mainly along, or normally to, the ledge; (3) the diffusion in both directions is small. The evaporation of NH_4Cl and of the monoclinic modification of As_2O_3 (claudetite) agrees with theoretical equations. In the case of arsenolith (cubic As_2O_3) the agreement is obtained if it is assumed that strong disturbances prevail inside the crystal. F. LACHMAN

536.423.1

1711. Rapid determination of the coefficients of exchange in boiling liquids. L. WEIL. Letter in *J. Phys. Radium,* **12,** 824–5 (*Oct.*, 1951) *In French.*

In order to determine the coefficient of exchange $\alpha = P/\theta$ it is sufficient to measure θ as function of t, and then to obtain the value of $P = (mc_p/s)(d\theta/dt)$, where P = power given up by a unit of area of the heating element, m = mass of the element, c_p = its specific heat, s = its area, θ = difference between the temperature of the element and that of the liquid, t = time. F. LACHMAN

536.423.15

1712. Measurement of the vapour pressure and condensation coefficients of iron, cadmium and silver. G. WESSEL. *Z. Phys.*, **130,** 539–48 (*No.* 4, 1951) *In German.*

The vapour pressure of Fe was measured, and by comparison with former measurements of evaporation rate the accommodation coefficient α was found to be unity. A direct method of measuring α is described and applied to Cd and Ag, for which $\alpha = 1$ within experimental error. L. G. CARPENTER

536.423.15

1713. The vapour pressure of argon. A. M. CLARK, F. DIN AND J. ROBB; A. MICHELS, T. WASSENAAR AND T. ZWIETERING. *Physica,* **17,** 876–84 (*Oct.*, 1951).

The vapour pressure of argon from pressures below 1 atmosphere to the critical point has been measured independently by observers in London and Amsterdam. At London the temperature was determined from the vapour pressures of oxygen. The cryostat and other apparatus used there is described. At Amsterdam the method and apparatus were the same as previously described [Abstr. 2444 (1948)]. The results of the two determinations are in satisfactory agreement with each other and with previous determinations, excepting that of Born. A.

536.423.15

1714. The vapor pressures of inorganic substances. VI. Vanadium between 1 666°K and 1 882°K. J. W. EDWARDS, H. L. JOHNSTON AND P. E. BLACKBURN *J. Amer. Chem. Soc.*, **73,** 4727–9 (*Oct.*, 1951).

For Pt V, see Abstr. 3488 (1951). The vapour pressure of V was determined by measuring the rate at which a metal surface evaporates into a vacuum. Values of ΔH_0^0 were calculated from individual vapour pressures and showed no appreciable trend, the average value being $121{\cdot}95 \pm 0{\cdot}14$ kcal. By combining this value with a linear expression in T for the difference in free energy functions between solid and gaseous V, the following vapour pressure equation was obtained: $R \ln p = -121{\cdot}95 \times 10^3 T^{-1} - 5{\cdot}123 \times 10^{-4}\,T + 36{\cdot}29$. A.

536.423.15

1715. The vapor pressures of inorganic substances. VII. Iron between 1 356°K and 1 519°K and cobalt between 1 363°K and 1 522°K. J. W. EDWARDS, H. L. JOHNSTON AND W. E. DITMARS. *J. Amer. Chem. Soc.*, **73,** 4729–32 (*Oct.*, 1951).

The vapour pressures of iron and cobalt have been determined by the vacuum evaporation method introduced by Langmuir. Heats of sublimation at the absolute zero have been calculated and equations formulated for vapour pressure as a function of temperature. The condensation (accommodation) coefficient has been found to be unity. A.

536.424.1

1716. Hysteresis in transitions in solids. D. G. Thomas and L. A. K. Staveley. *J. Chem. Soc.*, 1951, 2572–9 (*Oct.*).

It is pointed out that in transitions in solids hysteresis seems to be confined to those cases in which part, at least, of the change occurs almost isothermally, i.e. to those in which there is a stage in the transition when a new phase has to develop in one physically distinct from it. The theory of nucleation proposed by Turnbull has been applied to such transitions. The essential idea is that the initial development of the new phase is hindered both by the interphase-surface free energy and by the strain to which the growing nucleus is subjected, so that the temperature at which the two phases have the same molar free energies in bulk must be passed before the difference in bulk free energy outweighs the surface and strain effects and makes possible the appearance, at an observable rate, of self-propagating nuclei. The difficulties in the quantitative application of the theory are considered, but estimates are made of the range in which surface free-energy values would have to fall to account for observed hysteresis effects. The theory has been qualitatively used in a consideration of the factors which affect the width of hysteresis loops and the sharpness with which transitions set in, and also of observed phenomena within the loops. A.

536.44

1717. On the critical state of normal fluids. L. Goldstein. *Phys. Rev.*, **85**, 35–6 (*Jan.* 1, 1952).

It is shown, within the framework of the correlation liquid model, that in the space of relative momenta normal liquids have a distribution which leads to a condensation in this momentum space at the approach of their critical state. Other states do not exhibit this condensation process. A.

536.441

1718. The critical temperature and critical pressure of nitrogen. D. White, A. S. Friedman and H. L. Johnston. *J. Amer. Chem. Soc.*, **73**, 5713–15 (*Dec.*, 1951).

The critical constants of nitrogen have been determined by observation of the disappearance of the meniscus. The critical temperature is $126{\cdot}26 \pm 0{\cdot}04°$K and the critical pressure is $33{\cdot}54 \pm 0{\cdot}02$ atm. These results are compared with earlier vapour pressure data and with the critical constants estimated by extrapolation of P–V–T data. A.

536.453

1719. A solar furnace of 120-inches diameter for studying highly refractory substances. W. M. Conn. *Rev. Sci. Instrum.*, **22**, 945–51 (*Dec.*, 1951).

Previous work with large solar furnaces is reviewed. New developments in the design of the 120 in (3·05 m) solar furnace are discussed, in particular the mounting of the reflector, the parabolizing of the Al shell, and the production of a surface of high reflectivity. Close control of the temperature to which a sample is heated is attained by means of an Al cylinder which travels along the axis of the mirror and which controls the amount of radiation incident on the sample. Rotating sectors are used for separating the temperature radiation emitted by the sample and the incident radiation from the sun. Heating tests for obtaining molten materials, glasses and products of crystallization are discussed. Methods are presented for working approximating blackbody conditions at very high temperatures. A method for the accurate determination of melting points of highly refractory samples under pure conditions is presented. A.

536.46

1720. Electrical properties of flames. H. F. Calcote and R. N. Pease. *Industr. Engng Chem.*, **43**, 2726–31 (*Dec.*, 1951).

A study of the effect of longitudinal electric fields on the blow-off limits, dead space and flame pressure of Bunsen burner flames was undertaken to determine the nature of the effect and the significance of the abnormal concentrations of ions in flames. The results indicate that the electric field has a strong influence on the flame stability, the direction depending on the field polarity. A mechanical model in which momentum is transferred from positive ions to the gas qualitatively explains most of the results. The change in flame pressure indicates that the product of the ion concentration in ions/cm^3 and the flame thickness in cm is approximately 10^{10}, in agreement with the value calculated for transverse electric fields. For high negative electric fields it is assumed that the electrons acquire sufficient energy to raise the gas to an excited state. The large number of ions which must be present to produce these effects cannot be accounted for thermodynamically and are probably due to chemi-ionization, although they do not appear to play a significant role in the combustion process. A.

536.46 : 537.521.7

1721. Heat generation by electric sparks and rate of heat loss to the spark electrodes. W. Roth, P. G. Guest, G. von Elbe and B. Lewis. *J. Chem. Phys.*, **19**, 1530–6 (*Dec.*, 1951).

In a capacitance spark the gas between the electrodes is heated almost instantaneously, subsequently, the spark-generated heat flows from the gas to the material of the electrodes. In the present experiments sparks of 0·1 to 2 millijoules were passed between Pt electrodes in a bulb containing He or A or Xe, and either the pressure change, Δp, at constant volume v or the volume change, Δv, at constant pressure p was recorded. The spark-generated heat H residing in the gas at any instant was computed and from its values the discharge energy corresponding to the measured capacitance and break-down voltage, the percentage of spark-generated heat residing in the gas was obtained. Immediately after discharge the percentage was found to exceed 95. The rate at which the percentage decreases with time was found to be independent of total energy and vessel diameter above a critical value of the latter. It was found to become smaller with decreasing heat conductivity of the gas, decreasing diameter of the spherical electrodes, and increasing gap length, as expected on the basis of heat loss from the gas to the electrodes. With electrode dia. of 1 mm, the heat loss after about 30 msec ranged from a few percent for Xe and 10 mm gap length to 75% for He and 1 mm gap length. An increase of the electrode diameter to 3 and 4·6 mm caused a sub-

stantial increase of the rate of heat loss; for example, for Xe and 10 mm gap length the heat loss after about 30 msec was 28% and 35%, respectively. It was found that for constant electrode dia. the data for the several gases and gap lengths could be combined in a plot of percentage heat loss against a dimensionless parameter, v, representing the product of thermal diffusivity and time elapsed since discharge, divided by the square of the gap length. By means of the latter parameter, one may estimate an upper bound of the heat loss during the formation of a combustion wave from a spark in an explosive gas, i.e. during the process of spark ignition, on the basis that the combustion wave is formed in a time interval smaller than the time required for the wave to travel a distance equal to its width. It is found that the loss of spark energy during the ignition process is always rather small. A.

536.461

1722. On the one-dimensional theory of flame structure. R. FRIEDMAN AND E. BURKE. *J. Aeronaut. Sci.*, **18,** 239–46 (1951).

An investigation of the effects on the temperature and concentration distribution inside the flame zone, caused by a change in the spatial distribution of the rate of energy liberation and the rate of species formation, and by the variation of the heat conduction coefficient and the diffusion coefficient with temperature. The results show that the influences of the variations of the shape of rate distributions and the gas constants are not large. The authors suggest that the nondimensional relations obtained can be used to check the consistency of any one set of experimental data. MATHEMATICAL REVIEWS

536.461

1723. Polyhedral diffusion flames. J. E. GARSIDE AND B. JACKSON. Letter in *Nature* [*Lond.*] **168,** 1085 (*Dec.* 22, 1951).

Polyhedral diffusion flames are formed when a mixture of an inflammable gas and an inert gas is burnt in air; an example is given showing such a flame produced by a mixture containing 19·35% H_2 and 80·65% CO_2, burning in air. Previous observations of this polyhedral structure have been confined to aerated flames. A. SCHOFIELD

536.463

1724. Quantitative evaluation of rocket propellants. S. S. PENNER. *Amer. J. Phys.*, **20,** 26–31 (*Jan.*, 1952).

A method for the quantitative evaluation of chemicals as rocket propellants is described. The procedure utilizes the fact that adiabatic expansion through a nozzle may be considered to be isentropic. Treatments are presented for the two limiting conditions of expansion, corresponding to flow without chemical change and to flow which is characterized, at all times, by the existence of thermodynamic equilibrium. A.

536.48 : 533.16

The viscosity of gaseous He^3 at low temperatures. *See Abstr.* 1528

536.48 : 539.152.2

Alignment of cobalt 60 nuclei at very low temperatures. *See Abstr.* 2038

536.48 : 621.395.645 : 621.317.39

1725. The possibility for using an amplifier at low temperatures. A. N. GERRITSEN AND F. VAN DEN BURG. *Physica*, **17,** 930–2 (*Oct.*, 1951).

The gain of a 3-valve amplifier using low-consumption valves (9 mW per valve) fell to ⅓ of its room-temp. value at 20°K, due to a reduction of slope of the valves probably due to cooling of the ends of the filaments. Gain at low frequencies (< 1 000 c/s) was reduced much more, which was found to be due to a decrease in capacitance of the ceramic capacitors. The results indicate the feasibility of immersing a head amplifier of a measuring system in a cryostat.

536.48

1726. Evaporation rate of liquid helium I. A. WEXLER. *J. Appl. Phys.*, **22,** 1463–70 (*Dec.*, 1951).

In connection with a study of the emissivity of metals at low temperatures, a quantitative analysis has been made of the factors involved in the design of storage containers for liquid He. Experiments confirm the analysis, which has resulted in an exceedingly simple liquid-N-protected liquid He container having a He evaporation rate of 1% per day. The hemispherical emissivity of mechanically polished Cu at 4·23°K was determined for blackbody radiation. For radiation corresponding to that emitted by a blackbody at 77·1°K and 297·1°K, the measured emissivities are $6{\cdot}9\times10^{-3}$ and $1{\cdot}29\times10^{-2}$, respectively. These data are discussed in relation to the recent theoretical work of Reuter and Sondheimer. The heat of vaporization of He at 4·228°K was determined to be 4·93 cal g^{-1}, in substantial agreement with the data of Dana and Kamerlingh Onnes. Kistemaker's thermodynamic considerations questioning the accuracy of these data are evaluated in terms of the new determination. A.

536.48

1727. On the quantum mechanics of helium II. O. PENROSE. *Phil. Mag.*, **42,** 1373–7 (*Dec.*, 1951).

The quantum mechanics of a system of identical interacting particles must lead to the classical hydrodynamic equations of motion at high temperatures, because of the correspondence principle. On the other hand, the behaviour of He II shows that this is not always the case at low temperatures. It is shown that in certain cases the quantum description requires an extra parameter, which is the potential of a new velocity field superimposed on the classical motion. Expressed in semi-classical terms, the condition for the existence of this new parameter is that the probability, in the equilibrium state, of a particle having a very large de Broglie wavelength (that is, a negligible momentum) is finite. This condition is satisfied in one model of a superfluid system, a condensed Bose–Einstein gas, but not in a crystal. A tentative theoretical interpretation of two basic equations of the empirical two-fluid theory of He II is given, in which this new parameter determines the velocity of the superfluid. A.

536.48

1728. Second sound and the thermo-mechanical effect at very low temperatures. J. C. WARD AND J. WILKS. *Phil. Mag.*, **43,** 48–50 (*Jan.*, 1952).

At very low temperatures the phenomena of second

sound and the thermo-mechanical effect in liquid He may be described by using a phonon model independently of two-fluid concepts. A.

536.483

1729. Liquid air plant with propane precooling circuit. A. VAN ITTERNEEK and H. MYNCKE. *Meded. K. Vlaamse Acad. Wetensch. Belg.*, **13**, 12 *pp.* (*No.* 3, 1951).

After a short survey of existing plants the authors give the reason why they used propane as precooling agent. The liquid air plant is described and some measurements made on the compressors are quoted. A study is made of the rate of production, the yield and the kilowatt-hour consumption, in comparison with some other commercial plants. The authors obtain a yield of 15·6% of the weight of air taken in by the compressors under atmospheric pressure, for a precooling temperature of — 61°C. A.

536.483

1730. A finite difference treatment of a helium cryostat design problem. W. E. HENRY. *J. Appl. Phys.*, **22**, 1439–40 (*Dec.*, 1951).

A mathematical expression is derived from computing dimensions of a liquid He cryostat of specified performance characteristics. Use is made of a finite difference summation scheme applied to a simple thermomechanical model, using T as the independent variable, for a liquid evaporating in a container with good exchange to the walls. The scheme thus takes into account the heat capacity of the gas between the boiling point and the upper cryostat temperature. The results obtained are compatible with the actual performance of cryostats in operation. A.

536.483

1731. Low evaporation rate storage vessel for liquid helium. S. G. SYDORIAK AND H. S. SOMMERS, JR. *Rev. Sci. Instrum.*, **22**, 915–19 (*Dec.*, 1951).

Expressions are derived for the heat flux q_0 and temperature gradient dT/dh in a Pyrex cylinder (*a*) *in vacuo* and (*b*) in the atmosphere of cold vapour issuing from a liquid He container. In the temperature range $20 < T < 300$ it is found for case (*a*) that $q_0 \propto T^{1\cdot8}$ and $dT/dh \propto T^{-0\cdot8}$, while in case (*b*) $q_0 \propto T$ and dT/dh is nearly constant. Design details and operating procedures are given for a 12-litre liquid He storage vessel intended to complement a Collins's He liquefier. It can be filled in one day's operation of the liquefier, and ten days later is still half full. A.

536.483

1732. Measurement and control of the level of low boiling liquids. A. WEXLER AND W. S. CORAK. *Rev. Sci. Instrum.*, **22**, 941–4 (*Dec.*, 1951).

An account is given of a simple, reliable, and generally applicable electrical means for accurately measuring and controlling the level of low-boiling-point liquids. The sensitive elements exhibit at least a fivefold voltage difference for N and at least a five hundred-fold difference for He depending on whether they are in the liquid or the vapour. Heat transfer characteristics for liquid N are also noted. A.

536.5

1733. Bibliography on the measurement of gas temperature. P. D. FREEZE. *Circ. Nat. Bur. Stand., No.* 513, 14 *pp.* (1951).

The various temperatures which are of interest in hot gases moving at high velocities, such as those constituting the working media of gas turbines and jet engines, are reviewed in an introduction to a bibliography of approximately 400 references on the measurement of gas temperatures in general. These references, grouped for convenience in accordance with instrument types, cover approximately the last 20 years. A.

536.5 : 621.4/.5 : 621.317.319

1734. Measuring rapidly fluctuating gas temperatures. B. H. SCHULTZ. *Philips Tech. Rev.*, **13**, 104–8 (*Oct.*, 1951).

In the cylinders of high-speed heat engines, where one cycle lasts only a few hundredths of a second, very rapid fluctuations take place in the temperature of the gas, which are of great importance in the functioning of the engine but are almost impossible to calculate. It has been found possible to measure such rapid temperature fluctuations with the aid of an extremely fine metal wire connected as a resistance thermometer to an electric bridge. This wire, of a thickness of from 1·5 to 2 μ, responds to the variations in the temperature of the gas with a time-lag of only $1–1\cdot5\times10^{-4}$ sec. The fluctuations are recorded with the aid of an oscillograph: the oscillograms can be calibrated in a simple manner. The error in the measurement of the temperature is about 1°C, whilst the error in the phase angle is at most a few degrees. Measurements were made on an experimental single-cylinder air engine. A.

536.53

1735. A sensitive and reproducible thermometer in the range 2° to 20°K. A. BROWN, M. W. ZEMANSKY AND H. A. BOORSE. Letter in *Phys. Rev.*, **84**, 1050 (*Dec.* 1, 1951).

A suitably treated ½ W carbon resistor is cemented into a hole in a lump of niobium for calorimetric work. This element is very stable, weighs only 0·2 g, has a very stable calibration and is unaffected by magnetic fields up to 6 000 gauss. E. H. DOCK

536.532

1736. Temperature measurement in gases and flames—radiation methods. R. JACKSON. *B.C.U.R.A. Bull.*, **15**, 205–19 (*June*, 1951).

See Abstr. 6459 (1950). A critical review. The methods and pyrometers based on the measurement of total or partial radiation are discussed, in addition to line reversal methods for non-luminous flames. 63 refs. No diagrams. S. WEINTROUB

536.532

1737. Newer methods of gas temperature measurement. R. JACKSON. *B.C.U.R.A. Bull.*, **15**, 245–56 (*July*, 1951).

A critical review. Continuation of preceding abstract. The methods are those devised mainly for the measurement of the temperature of gases under unusual conditions such as experienced in gas turbine research. High temperature thermocouples; the high-velocity thermocouple pyometer; hot wire

methods; Pt resistance measurements; probe methods; methods based on gas composition, the measurement of gas density and the velocity of sound; and the "noise" thermometer are discussed. 70 refs.

S. WEINTROUB

536.532 : 535.2

1738. The thermoelement as a measure of radiation. L. GEILING. *Z. angew. Phys.*, **3**, 467–77 (*Dec.*, 1951) *In German.*

Thermoelements are now used extensively in infrared work. This paper gives an account of their basic principles and a critical discussion of recent developments in design. P. M. DAVIDSON

536.58 : 621.365.54 : 621.316.7

1739. Temperature regulation in induction heating. H. E. HENSCHEN, J. W. EDWARDS AND H. L. JOHNSTON. *Rev. Sci. Instrum.*, **22**, 987–8 (*Dec.*, 1951).

This paper describes an improvement in the design of a temperature regulator for induction heating. The improved design eliminates the optical lever by use of vacuum tube amplifiers. The result is to improve sensitivity and eliminate the large time constant of the galvanometer used in the earlier circuit. In experiments on vapour pressure of iron and cobalt at 1 200°–1 500°K, the new regulator held temperatures of the iron or cobalt samples constant to within about 0·1% of the absolute temperature. A.

536.581

1740. An apparatus delivering water at constant temperature. E. R. DYMOTT AND J. C. EVANS. *J. Sci. Instrum.*, **28**, 369–70 (*Dec.*, 1951).

An equipment is described which maintains the temperature of flowing water constant to within ± 0·01°C. On-off control is employed using a thermistor (or resistance thermometer) and Wheatstone network. Provision is made to attenuate the resulting temperature wave, and an additional thermistor in a compensating network is included to eliminate offset. A.

536.626, 536.633

1741. An all-glass calorimeter, and the heat of combustion of ethyl chloride. D. W. H. CASEY AND S. FORDHAM. *J. Chem. Soc.* (1951) 2513–16 (*Oct.*)

An all-glass calorimeter is described, suitable for determination of the heats of combustion of gases containing halogens. The heat of combustion of ethyl chloride vapour was determined as 341 ± 2·5 kcal/g-mol. at 20°. A.

536.628.2 : 541.64

1742. Calorimetry of high polymers. I. Automatic temperature recording and control of adiabatic jackets. M. DOLE, W. P. HETTINGER, JR, N. LARSON, J. A. WETHINGTON AND A. E. WORTHINGTON. *Rev. Sci. Instrum.*, **22**, 812–17 (*Nov.*, 1951).

Describes an adiabatic aneroid calorimeter for the measurement of the specific heat of high polymers over the temperature range — 20 to 300°C. The temperature of its adiabatic jacket can be automatically recorded and, for the most part, automatically controlled, thus making possible the convenient study of temperature drifts, heat exchanges and methods of correcting for such errors. Duplicate experiments have been carried out within an average deviation of 0·5 to 0·6% error, but the absolute error may be between 1 or 2%. A.

536.628.2 : 541.64

1743. Calorimetry of high polymers. II. Use of a watt-hour meter. M. DOLE, N. R. LARSON, J. A. WETHINGTON, JR AND R. C. WILHOIT. *Rev. Sci. Instrum.*, **22**, 818–20 (*Nov.*, 1951).

A method of using an alternating current watt-hour meter for the measurement of electrical energy in calorimetry is described. Reproducibility to better than 0·1% is readily obtainable, but the absolute accuracy depends upon the meter calibration. A.

536.631

1744. The specific heat of benzene at low temperatures. H. POULET. *C.R. Acad. Sci.* [*Paris*] **233**, 1272–3 (*Nov.* 19, 1951) *In French.*

Calculated values of the molecular heat of crystalline benzene are in good agreement with experiment between 0 and 100°K. Four fundamental frequencies are used in the calculations, $\nu_1 = 35\ cm^{-1}$, $\nu_2 = 63\ cm^{-1}$, $\nu_3 = 69\ cm^{-1}$, $\nu_4 = 105\ cm^{-1}$. Here ν_2 and ν_4 correspond to torsional oscillations about the axes of inertia in the plane of the molecule, and ν_1 and ν_3 about the six-fold axis perpendicular to the plane. The molecular heat is expressed in terms of Debye and Einstein functions. E. P. WOHLFARTH

536.631 : 535.375.5 : 539.11

1745. Evaluation of the specific heat of diamond from its Raman frequencies. D. KRISHNAMURTI. *Proc. Indian Acad. Sci. A*, **34**, 121–6 (*Aug.*, 1951).

The vibration spectrum is known to consist of eight discrete monochromatic frequencies followed by a continuous spectrum of elastic vibrations. Accordingly, the specific heat is expressed as the sum of eight Einstein functions, supplemented by three Debye functions representing respectively the three types of elastic vibration possible in the crystal. A close agreement is found between the calculated and the experimental values over the entire range of temperatures between 70° and 1 100°K. A.

536.631 : 548.7

The vibration spectra of crystals and the theory of their specific heats. *See Abstr.* 2248

536.633

1746. A new method for measuring the atomic heats of gases. H. S. GREGORY AND I. I. SHERIF. Letter in *Nature* [*Lond.*] **168**, 1123 (*Dec.* 29, 1951).

The theory of a modification of the heat transfer method [Gregory and Stephens, *Nature* [*Lond.*] **139**, 28 (1937)] taking into account the dependence of the accommodation coefficient, α, upon the pressure of the gas at low pressures, is described. A table of values of the atomic heat and of α over the temperature-drop range of pressure, for several gases at room temperatures, is given. S. WEINTROUB

THERMODYNAMICS 536.7/.8

536.7

1747. On the thermodynamics of irreversible processes. II. R. HAASE. *Z. Naturforsch.*, **6a**, 522–40 (*Oct.*, 1951).

For Pt I, see Abstr. 260 (1952). Over the range of validity of the phenomenological laws, the two laws of thermodynamics and the Onsager reciprocal

relations yield three statements regarding the occurrence of stationary non-equilibrium states, which are generalizations of suggestions due to Prigogine. From these it appears that the following general theorem may be proposed. "During the course of arbitrary transport phenomena in closed systems of a given temperature distribution, the (local) entropy production has a (positive) minimum value when a stationary non-equilibrium state is reached." It is suggested that the generalizations have an even more general significance, concerning the connection between the stability of stationary irreversible processes and the extreme value of entropy production than their derivation would appear to suggest. This conjecture is supported by the fact that the condition for the velocity of stable detonation waves may be deduced from the theorem. The extremal principles of Onsager are variational principles, i.e. extremal statements for virtual displacements under fixed accessory conditions that are not generally physically realizable. F. E. HOARE

536.7 : 530.162

Generalized statistical mechanics. *See Abstr.* 1486

536.7.1

1748. On a general thermodynamic theory of the equation of state. P. FOULKES. *Physica*, **17**, 943–52 (*Nov.–Dec.*, 1951).

On the basis of certain general conditions imposed on thermodynamic functions a general equation of state is derived in the form

$$v = \frac{T}{p}\phi\left(\frac{p}{T^{n+1}}\right) + h(p).$$ A.

536.71, 536.77

1749. Thermodynamic functions on the generalized Fermi–Thomas theory. M. K. BRACHMAN. Letter in *Phys. Rev.*, **84**, 1263 (*Dec.* 15, 1951).

In developing the equations of state of the elements, using generalized Fermi–Thomas theory, the pressure has been obtained by calculating the momentum flow rate through the atom surface. It may be obtained also from the free energy, and it is shown that the value so calculated agrees with that obtained by mechanical considerations. Expressions for the entropy and specific heat are also obtained. F. E. HOARE

536.721

1750. An improved mechanical equivalent of heat experiment. G. G. KRETSCHMAR. *Amer. J. Phys.*, **19**, 509–11 (*Dec.*, 1951).

A variation of Joule's experiment is described. It makes use of a rotary stirring mechanism for adding energy to water in a calorimeter, the energy being measured by a bifilar suspension of the driving motor. A.

ELECTRICITY 537

THEORY . ELECTRONS 537.1

537.12 : 536.1

1751. The influence of exchange energy on the specific heat of free electrons in metals. A. B. LIDIARD. *Phil. Mag.*, **42**, 1325–7 (*Nov.*, 1951).

A previous calculation [Abstr. 6467 (1950)] is extended by considering the second approximation to the Fermi distribution function and using a calculation of the exchange energy by Yokota [Abstr. 5536 (1950)]. The difference between the calculated specific heat and that obtained previously is found to be only 4%. E. P. WOHLFARTH

537.122 : 530.145

1752. The theory of the electron. II. W. WESSEL. *Z. Naturforsch.*, **6a**, 478–83 (*Sept.*, 1951) *In German.*

For a particle of minimal spin $\frac{1}{2}$, a rest-mass operator is determined for the author's classical electron theory [Abstr. 1862 (1947)] by a method depending on some new identities in the Dirac algebra. The operator obtained satisfies further a quantum condition recently found [Abstr. 1480 (1952)]. R. H. DALITZ

ELECTROSTATICS . DIELECTRICS 537.2

537.212 : 537.533.72 : 621.385.833

1753. Certain properties of electrostatic fields encountered in electron lenses. M. E. HAINE, G. LIEBMANN; P. A. LINDSAY. Letter in *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1012–13 (*Nov.*, 1951).

See Abstr. 8722 (1950). Reasons are given for doubting the existence of the points of inflection in the equipotential lines suggested in the earlier paper. These are rejected by Lindsay.

537.212 : 548.0

1754. Electrostatic fields in close-packed crystals. L. L. CAMPBELL, J. M. KELLER AND E. KOENIGSBERG. Letter in *Phys. Rev.*, **84**, 1256–7 (*Dec.* 15, 1951).

Fields are calculated for hexagonal close-packed and face-centred cubic crystals by approximating the metal as a collection of positive point changes immersed in a uniform negative charge distribution. P. T. LANDSBERG

537.221

1755. Contact potential differences. I. F. PATAI AND M. A. POMERANTZ. *J. Franklin Inst.*, **252**, 239–60 (*Sept.*, 1951).

A review with bibliography of 87 refs.

537.221

1756. Contact potential variations on freshly condensed metal films at low pressures. L. L. ANTES AND N. HACKERMAN. *J. Appl. Phys.*, **22**, 1395–8 (*Dec.*, 1951).

The reason for contact differences of potential is discussed. Since it is purely a surface phenomenon, subject to wide variation as the result of adsorbed and chemically combined surface layers, it is of interest to observe the change of contact potential as a function of time for various freshly evaporated metal films in high vacuums. The results thus obtained indicate characteristically different behaviour for each of the 6 metals studied. Electrical resistance measurements made on similar metal films under similar conditions are correlated with contact potential measurements. A.

537.221

1757. Volta potentials of the copper–nickel alloys and several metals in air. H. H. UHLIG. *J. Appl. Phys.*, **22**, 1399–1403 (*Dec.*, 1951).

Volta potentials of various metals approximately parallel the e.m.f. series. Metals abraded wet are more noble than when abraded dry, the transition metals changing an average of 0·28 V compared with 0·07 V for the non-transition metals owing possibly to the greater tendency of the transition metals to chemisorb O, especially in the presence of moisture. All metals change in the noble direction upon ageing in air, the average value being 0·3 V after 6 days. Potentials for Cu–Ni alloys, plotted with composition, fall on a sigmoid curve, whereas potentials for composite electrodes made up of separate Ni and Cu areas are linear with percent area of Ni exposed. Commercial Ni–Cu alloys above 50% Ni age more rapidly than laboratory alloys. The cause may lie in deoxidizers like Mg or Al, present in commercial alloys, but absent in the laboratory alloys. This suggests a non-destructive method for detecting impurities of this kind in metals. A.

537.221 : 621.317.32

1758. Measurement of contact potential. H. NEUERT. *Arch. tech. Messen, Issue No.* 189 (*Ref. V*3313–2) T 107 (*Oct.*, 1951) *In German.*

A brief review of the methods due to Kelvin, Meyerhof and Miller, Zisman and Rosenfeld and Hoskins. The "point of intersection" method of determining the anode–cathode contact potential in a valve is also described. C. F. PIZZEY (R)

537.224 : 621.3.011.4

1759. The capacitance of a circular annulus. W. R. SMYTHE. *J. Appl. Phys.*, **22**, 1499–1501 (*Dec.*, 1951).

Two formulas are derived for the capacitance of a flat circular annulus. The first has an accuracy of 1 part in 1 000 or better when the ratio of the external to the internal radius lies between 1·1 and ∞ and is exact at ∞. The second, $C = 34{\cdot}96R/\ln(32R/c)\ \mu\mu F$, has an accuracy of 1 part in 1 000 when the ratio lies between 1·000 and 1·1 and is exact at 1·000. In this formula c is the difference of the radii and R their mean value in meters. An approximate expression for the charge density is given in the first case. A.

537.226.1 : 621.3.011.5 : 621.315.613.1

1760. Electrical properties of Indian mica. IV. Electric strength. S. S. MANDAL. *Indian J. Phys.*, **25**, 111–22 (*March*, 1951).

For Pt III, see Abstr. 3024 (1948). The effect of thickness and preconditioning of specimens upon their electric strength has been studied. Their intrinsic strength is found to be independent of thickness as predicted in Fröhlich's theory of electronic breakdown in polar crystals. A.

537.226.2

1761. Dielectric properties of sodium, potassium and ammonium bicarbonates. C. T. O'KONSKI. *J. Amer. Chem. Soc.*, **73**, 5093–6 (*Nov.*, 1951).

The dielectric properties of these bicarbonates, determined from measurements on fine crystalline powders, indicate that the protons do not have the freedom postulated for certain other hydrogen-bonded solids. The effects of humidity are accounted for in the measurements and are attributed to formation of electrically conducting surface films by the adsorption of water. A.

537.226.2

1762. Phase transitions in solid solutions containing $PbZrO_3$. G. SHIRANE. Letter in *Phys. Rev.*, **84**, 854–5 (*Nov.* 15, 1951).

Curves of 1 Mc/s permittivity ν. temperature for (i) (Pb 92·5–Ba 7·5)ZrO_3 and (ii) (Pb 95–Sr5)ZrO_3 show a main Curie point peak together with a subsidiary step at lower temp. In the intermediate temp. range, d.c. bias considerably reduces ε for (i) but slightly raises it for (ii), while dynamic D–E curves show hysteresis for (i) but none for (ii). It is concluded that in this range (i) is ferroelectric, but (ii) is antiferroelectric. A phase diagram shows the ranges of paraelectric, intermediate and antiferroelectric phases for a range of compositions of the Pb–Ba and Pb–Sr zirconates. F. F. ROBERTS

537.226.2

1763. Dielectric relaxation in glycerol, propylene glycol and *n*-propanol. D. W. DAVIDSON AND R. H. COLE. *J. Chem. Phys.*, **19**, 1484–91 (*Dec.*, 1951).

Complex dielectric constants have been measured at frequencies from below 20 c/s to 5 Mc/s over the temperature range — 40° to — 75°c in glycerol, — 45° to — 90° in propylene glycol and — 80° to — 140° in *n*-propanol. The results for *n*-propanol are described by the Debye equation, but the values for the other two require a modified equation corresponding to a broader range of dispersion at higher frequencies. In all three liquids, evidence is found for a second dispersion region at still higher frequencies, which accounts for much of the difference between the radio frequency and optical dielectric constant. The relaxation times are quantitatively described over wide ranges by an empirical rate equation of a form which also fits viscosity data. The significance of the various results is discussed. A.

537.226.2

1764. The dielectric constant of ethylene at high pressures. H. G. DAVID, S. D. HAMANN AND J. F. PEARSE. *J. Chem. Phys.*, **19**, 1491–5 (*Dec.*, 1951).

The dielectric constant of ethylene has been measured at pressures up to 500 atm. and at temperatures of 25°c and 50°c. At both temperatures the Clausius–Mosotti function has been found to pass through a maximum with increasing density. The results have been discussed with reference to Kirkwood's theory of dielectric polarization. A.

537.226.2

1765. The dielectric constant of uranium hexafluoride at 9 400 Mc/sec. D. W. MAGNUSON. Letter in *J. Chem. Phys.*, **19**, 1614 (*Dec.*, 1951).

In a measurement of resonant frequency of a cavity filled with dielectric the lack of temperature variation of the molar polarization suggested zero dipole moment. J. JACOBS

537.226.2

1766. Erratum: Errata: The dielectric constant of water and the saturation effect. F. BOOTH. *J. Chem. Phys.*, **19**, 1615 (*Dec.*, 1951). See Abstr. 272 (1952).

537.226.2 : 536.48

1767. Adiabatic thermal changes in barium titanate ceramic at low temperatures. R. W. SCHMITT. *Phys. Rev.*, **85**, 1–4 (*Jan.* 1, 1952).

The adiabatic thermal changes at 4°K in barium titanate ceramic show a heating effect whether the electric field is applied or removed. An interpretation of these results is that the polarization process is thermodynamically irreversible. The large temperature-dependence of the dielectric constant at 4°K may be understood as a result of the thermodynamically irreversible polarization. Quantitative results are given as to the temperature rise as a function of electric field strength and as a function of temperature.

A.

537.226.2 : 621.3.011.5 : 621.315.615

1768. Table of dielectric constants of pure liquids. A. A. MARYOTT AND E. R. SMITH. *Circ. Nat. Bur. Stand., No.* 514, 44 *pp.* (1951).

The "static" dielectric constants of more than 800 substances in the liquid state were critically examined and tabulated in concise form. The table consists of three sections: (1) standard liquids; (2) inorganic liquids; and (3) organic liquids. An indication of the probable accuracy of the data is given. Wherever feasible, a simple analytical function is employed to express the variation of dielectric constant with temperature.

A.

537.226.2 : 621.317.335.3.029.63 : 621.392.26

1769. The concentric hollow conductor as a measuring instrument in the decimetric-wave region. H. JUNGNICKEL AND H. FALKENHAGEN. *Ann. Phys.* [*Lpz.*] **9**, 341–56 (*No.* 6–7, 1951) *In German.*

Theoretical and practical aspect of determination, by means of probes introduced into a concentric hollow conductor, of complex dielectric constants and permeabilities in the region of decimetric waves.

Z. F. WOJNAR

537.226.2 : 679.5 : 621.3.011.5 : 621.315.616.9

1770. Dielectric behaviour of plastics. F. H. MÜLLER. *Kunststoffe*, **41**, 277–83 (*Sept.*, 1951) *In German.*

A review, stressing the fact that available knowledge on the subject has not been fully exploited as yet, and the question of how far a completely loss-free substance can be produced is discussed. Dielectric theory predicts that the limit for organic material lies around a loss factor of $\tan\delta = 10^{-4}$, on account of partial orientation of dipoles, due to thermal motions. These fluctuations are larger in organic than in inorganic materials and so it should be possible to obtain inorganic materials (pure crystals) of lower loss than any organic material. 29 refs.

INDEX AERONAUTICUS

537.226.3

1771. Low-frequency dielectric absorption and direct current conductivity in quinol. J. S. DRYDEN AND R. J. MEAKINS. Letter in *Nature* [*Lond.*] **168**, 1121–2 (*Dec.* 29, 1951).

Low frequency absorption and direct current conductivity in compressed disks of quinol decreasing with time, are attributed to random H-bond formation introduced in grinding the crystals in contrast to the normal regular hexagonal arrangement of H-bonds which are lossless.

D. H. WHIFFEN

537.226.3 : 537.311.32 : 548.0

1772. The effect of inhomogeneities on the electrical properties of diamond. A. J. AHEARN. *Phys. Rev.*, **84**, 798–802 (*Nov.* 15, 1951).

To account for the non-uniformities in the electrical properties of diamond, particularly those observed in bombardment conduction, the proposal is made that the well-known lattice imperfections are not distributed homogeneously in the physical crystal, and that the resulting fluctuations in the height of the energy bands relative to the Fermi level might produce interspersed "pools of mobile charge" separated by barriers within the diamond. These pools and barriers should lead to dielectric losses at high frequencies. A single conducting channel, in series with a barrier, could be represented by a series resistance R_s and capacity C_s or by the equivalent parallel resistance R_p and capacity C_p. With some, but not all, diamonds measurable dielectric losses at 70 Mc/s were observed. R_p varied from 5×10^6 ohms, the limit of measurement, to 4×10^5 ohms. Furthermore, the proposed model suggests that, in some cases, these barriers might be sufficiently lowered to establish a d.c. conducting channel all the way through a crystal. With a few of the lossy diamonds precisely this phenomenon of "high conduction" has been observed, in which a resistance of the order of a megohm is obtained with a d.c. voltage applied. This current appears abruptly in time but it lags behind the application of the voltage. This lag is influenced by irradiation with light or α-particles or by previous treatment. The proposed pools of mobile charge are a sufficient but not necessary description of the dielectric loss observations, but the high conduction phenomenon lends further support to this idea of conducting channels with barriers in lossy diamonds. Such localized conducting channels would introduce inhomogeneities into an otherwise uniform electric field applied across an insulator. In bombardment conduction, measurements of counting efficiency could be very sensitive to field inhomogeneities. Under α-particle bombardment a large variation in counting efficiency over the surface of typical diamonds is shown. In a group of 20 diamonds, most of those that exhibited definite losses also had high ($\geq 25\%$) counting efficiencies in some region, and the majority of the remainder had low counting efficiencies. These experiments lend further support to the suggestion that inhomogeneous fields at least partially account for the inhomogeneities in bombardment conduction. Serious errors in the normal estimates of range and mobility of electrons or holes in insulators can be introduced by neglecting these field inhomogeneities.

A.

537.226.8

1773. Influence of shear on the dielectric constant of liquids. B. L. FUNT AND S. G. MASON. *Canad. J. Chem.*, **29**, 848–56 (*Oct.*, 1951).

The effects of a velocity gradient upon the dielectric constant were studied in solutions of macromolecules, in suspensions and in liquid crystals. Decreases under shear were observed for polar polymers in polar and nonpolar solvents. For solutions of ethyl cellulose an increase in dielectric constant was obtained. Non-

polar polymers showed no changes of dielectric constant under shear. Large changes in dielectric constant at low rates of shear were observed in carbon black suspensions. The experimental results are discussed on the basis of particle orientation in a velocity gradient and in an electric field. A.

537.226.8

1774. The permanently polarized dielectric. F. BINDER. *Z. Naturforsch.*, **6a**, 714–18 (*Nov.*, 1951) *In German.*

The concept of the electret formulated by Heaviside and first demonstrated by Eguchi is discussed and illustrated by measurements on polyvinyl chloride using a demountable capacitor [Gross, Abstr. 296 (1951)]. Confirmation that the homocharge is formed by discharges between the electrode and the dielectric surface is provided by dusting the surface with suitable powders, and the patterns show that the surface is not uniformly charged. Possible applications of electrets are briefly discussed. J. H. MASON

537.226.8 : 536.424

1775. Is the ferroelectric 120°C transition of barium titanate first or second kind? W. KÄNZIG AND N. MAIKOFF. *Helv. Phys. Acta*, **24**, 343–56 (*No.* 4, 1951) *In German.*

The phenomenological theory of Devonshire predicts that the transition is of the first kind. To prove this the effect of a biasing field on the dielectric constant of single-domain crystals has been investigated in the temperature-range from 20° to 180°C. The experimental results confirm the theory. The 120°C transition appears to be an adiabatic transition of the first kind. A.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.3 : 621.38

1776. On unified theories of thermal and shot noise. S. DEB. *Indian J. Phys.*, **25**, 391–402 (*Aug.*, 1951).

Presents an outline of the principal characteristics of the thermal and the shot types of noise (in circuits and in valves respectively) and examines the similar features of the two phenomena. The unified theories of the two types of noises proposed recently by Campbell and Francis, and by Fürth are reviewed and discussed critically. The phenomenon of space-charge-reduction of noise has been explained from a new statistical standpoint. It is shown that although the two types of noises owe their origin to the same basic phenomenon, they differ in one essential respect, viz. the presence of thermal equilibrium in the one and not in the other. It is concluded that thermal noise can be looked upon as a special case of shot-noise when thermal equilibrium exists. As such, the unified thermo-dynamical theory of Fürth becomes unacceptable. A.

537.311.1 : 537.312.62

1777. Application of collective treatment of electron and ion vibrations to the theories of conductivity and superconductivity. D. BOHM AND T. STAVER. Letter in *Phys. Rev.*, **84**, 836–7 (*Nov.* 15, 1951).

To the collectively describable part of the plasma vibrations [Abstr. 5379 (1951)] must be added a randomly fluctuating part associated with the individual particles which causes each electron to be followed by an acoustical "wake." Energy dissipated in this wake gives the resistance. The wake also gives rise to an interaction of electrons following each other of a similar character as in Fröhlich's and Bardeen's theory of superconductivity. H. LONDON

537.311.33

1778. On the activation energy of impurity semi-conductors. H. K. HENISCH. *Z. phys. Chem.*, **198**, 41–51 (*No.* 1–4, 1951) *In German.*

Methods of evaluating activation energies from measurements of the temperature variation of conductivity, Hall coefficient and thermoelectric power are discussed. The influence of impurities and heterogeneity in various samples is considered, together with the effects on the measured values to be expected as a consequence of intergranular contacts. It is shown that for a large number of specimens of the same substance a whole range of energies would probably be obtained. Experiments whose results would solve some of the outstanding problems in this field are proposed. C. A. HOGARTH

537.311.33

1779. On the present state of the theory of contact rectifiers. P. T. LANDSBERG. *Z. phys. Chem.*, **198**, 75–88 (*No.* 1–4, 1951) *In German.*

A critical discussion. It includes the derivation of a formula for the barrier capacitance when the space charge is voltage-dependent. A differential equation for the electric field in the barrier is also set up, and some of its properties are discussed. The importance of inhomogeneous distributions of impurity centres is stressed. P. T. LANDSBERG

537.311.33

1780. Localized electronic states in bombarded semi-conductors. H. M. JAMES AND K. LARK-HOROVITZ. *Z. phys. Chem.*, **198**, 107–26 (*No.* 1–4, 1951).

The effects of bombardment of Si and Ge with fast α-particles, deuterons, neutrons or electrons, are described and discussed in the light of the effects of vacancies and substitutional impurities in the lattices. It is considered that lattice vacancies in Ge and Si will act as acceptors and interstitial atoms as donators for more than one electron, i.e. interstitials show several increasing electron ionization energies, and vacancies several successively increasing hole ionization energies. In Ge the second electron ionization energy is 0·75 eV and the second hole ionization energy is 0·2 eV. For Si the values are 1 and 0·75 eV respectively. C. A. HOGARTH

537.311.33

1781. Variations of capacity of selenium rectifiers and ionization balance of trapping centres. K. LEHOVEC AND O. IMALIS. *Z. phys. Chem.*, **198**, 127–46 (*No.* 1–4, 1951) *In German.*

Details of the capacity measurements on Se rectifiers at 5 000 c/s and with 10 mV applied to the bridge, are given. The variations caused by electric fields applied in the reverse direction and by irradiation with light are described, and discussed in terms of the equilibrium conditions for traps in the barrier

region. It is considered that about 10^{11} cm^{-2} surface traps are active and that the capture cross-section of an electron in a trapping site is about 10^{-11} cm^2.

C. A. HOGARTH

537.311.33

1782. Disorder model for a semiconductor with characteristic defect centres, taking chromium sesquioxide as an example. K. HAUFFE AND J. BLOCK. *Z. phys. Chem.*, **198**, 232–47 (*No.* 5–6,1951) *In German.*

The variations of free carrier concentration for various types of metallic oxide are summarized on the basis of the Schottky–Wagner "Fehlordnungstheorie," and include the behaviour of "characteristic" semiconductors in which deviations from stoichiometric proportions or changes in oxygen pressure cause an effect due to equal numbers of free electrons and holes (e.g. CuO). The very small oxygen partial-pressure dependence of electrical conductivity σ of Cr_2O_3 arises from the relatively high value of σ and not from the usual mechanism for an impurity semiconductor. The disorder model is deduced from the theory for mixed-oxide semiconductors. By the strong change in σ for substituted oxides of higher valency (e.g. TiO_2 and WO_3) it is possible to estimate the disorder concentration for the pure phase, the hole mobility and the energy to distort the lattice. The non-dependence of σ of Cr_2O_3 on ZnO substitution indicates the possibility of preferred ionic disorder.

C. A. HOGARTH

537.311.33

1783. On disorder phenomena and conduction processes in characteristic semiconductors. K. HAUFFE AND H. GRUNEWALD. *Z. phys. Chem.*, **198**, 248–57 (*No.* 5–6, 1951) *In German.*

See preceding abstract. The disorder phenomena in CuO are investigated with the aid of small quantities of substituted Cr_2O_3, Li_2O, Y_2O_3 and ZrO_2, and a theory of the effects is given. The mechanism of conduction in spinels such as Fe_3O_4 is also discussed.

C. A. HOGARTH

537.311.33

1784. The copper oxide rectifier. W. H. BRATTAIN. *Rev. Mod. Phys.*, **23**, 203–12 (*July*, 1951).

It is shown that the conductivity in the ohmic part of the cuprous oxide layer can be explained with the usual band picture of semiconductors only by assuming the presence of some donor-type impurities in addition to the usual acceptor type. The energy difference between the acceptors and the filled band is 0·3 electron volt, and the total number of impurity atoms is about 10^{14} to 10^{16} per cm^3, the number of donors being less than but of the same order as the number of acceptors. Applying the Schottky theory of the space charge exhaustion layer, one finds from the dependence of capacity of the rectifier on bias voltage that the density of ion charge in the rectifying layer is of the same order of magnitude as the difference between the donors and acceptors found from the conductivity, thus furnishing a check for the theory. The field at the copper/cuprous oxide interface calculated from the space charge is about 2×10^4 V/cm; the height of the potential at the surface as compared with the oxide interior is about 0·5 V; and the thickness of the space charge layer about 5×10^{-5} cm. The diffusion equation for flow of current through this space charge region can be integrated to give the current in terms of the field at the interface and the applied potential across the space charge layer. Two currents are involved, one from the semiconductor to the metal (I_s) and one from the metal to the semiconductor (I_m) which is similar to a thermionic emission current into the semiconductor. The net current is, of course, $I = I_m - I_s$. One can get this "emission" current (I_m) by dividing the true current by the factor $1 - \exp(-eV_a/kT)$, where V_a is the applied potential. This emission current depends on the absolute temperature and on the field at the copper/cuprous oxide interface. At high fields the logarithm of the current is proportional to the square root of the field, and at low fields the current decreases more rapidly indicating a patchy surface having small areas of low potential maximum from which all the emission comes when the field is large. This effective potential maximum measured from the Fermi level in the copper is about 0·5 eV, and the fraction of the total area effective ranges from 10^{-2} to 10^{-5} depending on how the rectifier was made. This last factor—the fraction of the area having this low potential maximum—is by far the most important variable, resulting in low reverse current when the fraction is small and large reverse current when the fraction is large. A.

537.311.33

1785. The effect of the mean free path of electrons on the electrical properties of non-metals. R. W. WRIGHT. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 984–99 (*Nov.*, 1951).

The theories of the mean free path of electrons in various types of materials, under various conditions, are discussed. The conductivity, thermo-electric power, Hall coefficient, fractional change of conductivity in a magnetic field, and the Nernst, Ettinghausen and Righi–Leduc coefficients are all calculated upon the Lorentz–Sommerfeld theory for the various mean free path theories. The variations are discussed with particular respect to the changes of the reduced chemical potential η^*. The magnitude and sign of the coefficients are found to depend upon the mean free path theory assumed, that is, upon the type of material. In particular it is shown that the Ettinghausen and Nernst coefficients should be negligible in the majority of semiconductors with ionic lattices. Some of the assumptions usually made in semiconductor theory are shown to lead to erroneous conclusions. Experimental evidence is discussed and is found in general to support the theory given, both in impurity metals and semiconductors, except perhaps in the case of the thermo-electric power. No experimental results in non-metals are known for the thermo- and galvano-magnetic effects apart from the Hall coefficient, and it appears likely that such measurements will produce interesting information. A.

537.311.33

1786. A study of rectification effects at surfaces of germanium and lead sulphide. C. A. HOGARTH AND J. W. GRANVILLE. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 992–8 (*Nov.*, 1951).

Previously reported [Abstr. 6968 (1951)] results of polishing and chemically etching the surfaces of Ge crystals are confirmed. The effects of vacuum heat

treatment are investigated and it is found that treatment of this kind at temperatures between 500 and 900°C can improve the rectification characteristics considerably. The treatment does not spoil the optical quality of a polished surface, and in this connection may provide an advantage over chemical etching. Similar effects are obtained with deficit-conducting PbS. Modifications to the surface structures of the crystals by various treatments are investigated by electron diffraction. A.

537.311.33

1787. Electron-hole production in germanium by alpha-particles. K. G. McKay. *Phys. Rev.*, **84**, 829–32 (*Nov.* 15, 1951).

The number of electron-hole pairs produced in Ge by alpha-particle bombardment has been determined by collecting the internally produced carriers across a reverse-biased *n–p* junction. No evidence is found for trapping of carriers in the barrier region. Studies of individual pulses show that the carriers are swept across the barrier in a time of less than 2×10^{-8} sec. The counting efficiency is 100%. The energy lost by an α-particle per internally produced electron-hole pair is $3{\cdot}0 \pm 0{\cdot}4$ eV. The difference between this and the energy gap is attributed to losses to the lattice by the internal carriers. It is concluded that recombination due to columnar ionization is negligible in Ge. A.

537.311.33

1788. Evidence for the production of hole traps in germanium by fast neutron bombardment. J. W. Cleland, J. H. Crawford, Jr, K. Lark-Horovitz, J. C. Pigg and F. W. Young, Jr. Letter in *Phys. Rev.*, **84**, 861 (*Nov.* 15, 1951).

A model due to James and Lehman [Abstr. 7860 (1951)] is in qualitative agreement with the experimentally determined relation between conductivity and incident neutron flux for low resistivity *P*-type Ge single crystals. The assumption is that bombardment introduces donors and acceptors in equal quantities below the middle of the forbidden band [not the filled band as stated], so that the Fermi level will attain a limiting value ξ_0 after sufficient bombardment. If this is measured from the top of the filled band, the inequality $0{\cdot}168\text{ eV} > \xi_0 > 0{\cdot}105\text{ eV}$ is obtained from the experimental data. P. T. Landsberg

537.311.33

1789. Variations, as functions of temperature and applied potential, of the electrical resistance of very thin metallic films deposited on diamond, amber and Plexiglass. N. Mostovetch and T. Duhautois. *C.R. Acad. Sci.* [*Paris*] **233**, 1265–7 (*Nov.* 19, 1951) *In French.*

By means of careful experiment the laws found previously [Abstr. 7887 (1951)] for thin films deposited on glass, quartz and mica are confirmed. It is concluded that the semiconductive behaviour observed with these films is not due to impurities derived from the substrate material. C. A. Hogarth

537.311.33

1790. Electric forming of *n*-germanium transistors using donor-alloy contacts. R. L. Longini. Letter in *Phys. Rev.*, **84**, 1254 (*Dec.* 15, 1951).

The process of electrical forming may consist in producing a *p–n* hook region [Abstr. 6965 (1951)] near the probe by the combination of lattice vacancies and phosphorus impurity atoms, both diffused into the germanium from the collector probe. A. D. Le Claire

537.311.33 : 537.312.5

1791. On localized decreases of resistance in photoconductive layers. H. Müser. *Z. phys. Chem.*, **198**, 52–60 (*No.* 1–4, 1951) *In German.*

The effect of light in decreasing the resistance of layers of semiconducting material may be explained as a consequence of two mechanisms, a liberation of free carriers in the crystals and a lowering of potential barriers between the grains. Theoretical formulae are developed and illustrated by means of experiments on PbS films. C. A. Hogarth

537.311.33 : 535.371

1792. New views on oxidic semi-conductors and zinc-sulphide phosphors. E. J. W. Verwey and F. A. Kröger. *Philips Tech. Rev.*, **13**, 90–5 (*Oct.*, 1951).

Following upon a brief discussion of the semiconducting elements Si and Ge and of non-stoichiometric oxidic semi-conductors, the "method of controlled valency" is described by taking NiO as an example. This method consists in bringing about desired changes in valency by the admixing of suitable "impurities." There is a great similarity in the mechanism of conductance between non-stoichiometric semi-conductors and other semi-conductors prepared by the method of controlled valency. Compared with the former, the latter group, however, possess great advantages, which are to be ascribed to the lack of thermal stability of non-stoichiometric compounds. This lack of stability is due to the fact that in non-stoichiometric compounds there are always vacant sites in the lattice. Somewhat similar considerations apply to ZnS phosphors. After the part played by halogen ions in the formation of these substances had been realized, a better picture could be formed of the fluorescent centres: the centres are formed by an activator ion surrounded by S ions. The accuracy of the hypothesis developed finds confirmation in the possibility of having the part played by the halogen ions taken over by trivalent cations. This opens the way to the production of entirely new phosphors. A.

537.311.4

1793. The work functions of copper, silver and aluminium. E. W. J. Mitchell and J. W. Mitchell. *Proc. Roy. Soc. A*, **210**, 70–84 (*Dec.* 7, 1951).

The work functions of surfaces produced by the deposition of thin films of the metal from the vapour on to previously well-aged W surfaces, have been found to be: $4{\cdot}61 \pm 0{\cdot}04$, $4{\cdot}35 \pm 0{\cdot}05$ and $4{\cdot}25 \pm 0{\cdot}05$ eV respectively. These values are based on measurements of the contact difference of potential between these metals and W, made by the retarding potential method. The conditions which have to be satisfied if reliable results are to be obtained with this method are discussed and the construction of an efficient low-velocity electron gun is described. A.

537.312

1794. Direct evidence for the conductivity of a thin dielectric specimen subjected to an electronic bombardment. C. Dufour, A. Herpin and J. P. Thomas. Letter in *J. Phys. Radium*, **12**, 887–8 (*Nov.*, 1951) *In French.*

Experiments on triple layers Al–ZnS–Al are described. The layers, being very thin, enable effects due to induced conductivity to be measured as opposed to effects due to a superficial space-charge layer such as one finds on thicker specimens. C. A. HOGARTH

537.312.5

1795. Optical absorption and photoconduction in ZnO. E. Mollwo. *Z. phys. Chem.*, **198**, 258–62 (*No.* 5–6, 1951) *In German.*

The photosensitive range of ZnO lies in the absorption region. The photoconductive electrons are not derived from ground-band excitation but from the excess Zn^+ ions, by the reaction $Zn^+ \xrightarrow{opt} Zn^{++} + e^-$. The quantum efficiency is determined and a sphere of interaction for light and Zn^+ ions is calculated. This is found to be more than ten times the ionic volume.

C. A. HOGARTH

537.312.5

1796. Photoelectric lithium–antimony cathodes. N. Schaetti and W. Baumgartner. *Vide*, **6**, 1041–5 (*July–Sept.*, 1951) *In French.*

The thermionic emission of Li–Sb is much less than that of a Cs–Sb cathode. This makes the Li compound suited for work in the violet and u.v. region, particularly as the cathode of scintillation counters. The photoelectric properties are given and the performance of a Li–Sb photomultiplier is discussed. The thermionic emission (dark current) is 4×10^{-17} A for Li–Sb and 2×10^{-15} A for Cs–Sb. W. SUMMER

537.312.5

1797. Photoconductivity in amorphous selenium. P. K. Weimer and A. D. Cope. *RCA Rev.*, **12**, 314–34 (*Sept.* (I), 1951).

Studies of photoconductivity in this material by television scanning techniques and by conventional methods have shown it to possess interesting and unusual properties. Sustained photocurrents, generated at one electrode and approaching unity quantum yield, are obtained through evaporated Se films which are highly insulating in the dark. Hole conduction is predominant over electron conduction, the range of the holes in the Se exceeding 10^{-3} cm. The spectral response is a maximum at 4 000–4 500 Å and extends into the far ultraviolet. The maximum response does not coincide with the optical absorption edge, as is usually the case; the absorption edge occurs at much longer wavelengths (6 000 Å). The time constant for the rise and decay of photocurrent is less than 50 μsec. Space-charge-limited currents are observed with excess light for low fields across the material. Evidence for primary and secondary photocurrents is discussed. The application of the television scanning method to photoconductive measurements is presented and its advantages and limitations are discussed. A.

537.312.5

1798. Properties of some photoconductors, principally antimony trisulfide. S. V. Forgue, R. R. Goodrich and A. D. Cope. *RCA Rev.*, **12**, 335–49 (*Sept.* (I), 1951).

The electrical properties of a photoconductor necessary to fit it for use as a television pickup tube target material are outlined. Red Sb_2S_3 has been studied extensively and found to satisfy many of the requirements. Plots of the variation of dark current with voltage and of photocurrent with light for this material are given. Its spectral response, sensitivity and quantum efficiency are discussed. These and other physical properties of Sb_2S_3 pertinent to its use as a photoconductor may be affected by impurity addition, heat treatment and method of preparation. It has been found possible to form a single photoconductive layer from combinations of two different sulphides or selenides having useful electrical properties intermediate between those of the constituents. A.

537.312.5

1799. Some aspects of the photoconductivity of cadmium sulfide. R. W. Smith. *RCA Rev.*, **12**, 350–61 (*Sept.* (I), 1951).

Measurements of the photoconductive behaviour of CdS crystals are described and include: photocurrent *versus* irradiation curves, time constant observations, Hall effect measurements, and probe examinations of the potential distribution. These are mainly aimed at determining how well the expression for quantum yield θ = (life time of a free carrier)/(transit time of a free carrier) can be satisfied. If the observed time constant is used as a measure of the life time of a free carrier, the discrepancy is over four orders of magnitude at low lights and may be reduced to one order of magnitude or less at high lights. Trapping effects are believed to be responsible for the lack of complete agreement. A capture cross-section of primary centres for free electrons is computed from the data to be 10^{-21} cm^2. A.

537.312.5

1800. An outline of some photoconductive processes. A. Rose. *RCA Rev.*, **12**, 362–414 (*Sept.* (I), 1951).

An attempt is made to outline processes in such form as to facilitate quantitative comparison with experimental data. The processes include space-charge-limited currents and volume-excited currents. The latter takes on a variety of forms depending on the presence and distribution of traps, the mobility of one or both kinds of carriers and the ease of replenishing these carriers at the electrodes. Most emphasis is placed on insulators and on trapping effects in insulators. The concept of a steady-state Fermi limit is introduced to aid the anlysis. Also, two time constants are separated out: the observed decay time for the photocurrent, and the mean life time of a free carrier. It is found that the following observed data can readily be accounted for: current *versus* light curves with exponents between 0·5 and 1·0; the lack of reciprocity between sensitivity and speed of response; and the low values of currents excited in thin evaporated insulating films by light or electron bombardment. The ratio of life time of a free carrier to the observed time constant is proposed as a figure of merit for a photoconductor. Other items discussed are infrared quenching, spectral response, non-uniform illumination of semiconductors and the

effects of barrier fields on photoconductivity. It is suggested that these barrier fields may have a larger influence on photoconductivity by reducing capture cross-sections than by shortening the effective length of photoconductor. A.

537.312.5

1801. On the temperature dependence of the photoelectric conductivity of CdS. E. A. Niekisch and R. Rompe. *Z. phys. Chem.*, **198**, 200–14 (*No.* 1–4, 1951) *In German.*

A theoretical semi-quantitative discussion of experiments by Niekisch [Abstr. 5415 (1951)]. The discussion deals with two facts: (1) That the absorbed energy (A) is related to the total photocurrent (J) through temperature-dependent constants α, β; $A = \alpha J + \beta J^2$, where α/β decreases with temperature. (2) That for fixed incident energy density per sec the temperature dependence of the photocurrent shows a maximum. The provisional explanation utilizes the notion of radiationless transitions and of electron energy levels in the forbidden band.

P. T. LANDSBERG

537.312.5

1802. The long-wave limit of infra-red photoconductivity in PbSe. A. F. Gibson, W. D. Lawson and T. S. Moss. Letter in *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1054–5 (*Nov.*, 1951).

Layers prepared in a suitable manner were found to have limits at $4{\cdot}7\mu$ at room temperature and $6{\cdot}8\mu$ at 90°K. These correspond to the observed absorption edges and are substantially longer than for PbTe.

537.312.5

1803. The $n-p-n$ junction as a model for secondary photoconductivity. K. G. McKay. *Phys. Rev.*, **84**, 833–5 (*Nov.* 15, 1951).

A Ge $n-p-n$ junction with the p region floating, has been subjected to alpha-particle bombardment. The transient currents resulting from individual incident alphas have been studied. This enables one to study the rate of decay of excess holes in the p-region. This decay time appears to increase with applied bias, pass through a maximum, and eventually approach a constant value. The total charge flowing across the unit, as a result of the bombardment by a single alpha-particle, may become large; quantum yields of greater than 60 have been observed. The unit possesses many of the important characteristics of materials which exhibit "secondary photoconductivity." It is concluded that various forms of $n-p-n$ barriers must therefore play an important role in such materials and that their understanding can be greatly facilitated by studies of $n-p-n$ barriers in Ge. A.

537.312.5 : 535.343.2

1804. Photoconductivity of trapped electrons in KBr crystals at room temperature. J. J. Oberly. Letter in *Phys. Rev.*, **84**, 1257–8 (*Dec.* 15, 1951).

A discussion of measurements on the photoconductivity and absorption as a function of wavelength of the F and M colour-centre absorption bands produced by X-irradiation of KBr crystals and of the L, R and N bands produced on subsequent bleaching by exposure to "F-light" of 6 250 Å. The effect was studied on all 5 bands of varying the amount of F-light exposure. The behaviour of the F and M bands during bleaching suggests that each is produced by a combination of hard (non-bleachable, non-photoconductive) and soft (bleachable, photoconductive) components of the associated F and M centres. A. D. LE CLAIRE

537.312.6

1805. Electrical conductivity of metals at low temperatures: equilibrium between electrons and phonons. P. G. Klemens. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1030–9 (*Nov.*, 1951).

The Bloch theory of electrical conductivity of metals assumes that the phonon distribution does not deviate from equilibrium. Peierls has criticized this assumption, showing that in the presence of an electric field a stationary state is achieved only through processes which do not conserve the total wave vector. These can be *Umklapprozesse* involving electrons and a phonon, or phonon–phonon interaction of the type responsible for thermal resistance in dielectric solids. He estimates that if only the latter were to act, strong deviations from Bloch's formula would occur below 50°K. He therefore concludes that the electrical resistance at low temperatures is determined by *Umklapprozesse*. A more detailed treatment of the statistical equilibrium of phonons and electrons shows that the relaxation times of the important phonons is smaller than estimated by Peierls by a factor of about 100; consequently one would not, as a result of phonon–phonon interactions, expect important deviations from the Bloch theory above 10°K. It is thus unnecessary to consider *Umklapprozesse*. Since *Umklapprozesse* require a special shape of the Fermi surface in wave-vector space, Peierls has concluded from the apparent agreement with Bloch's theory that the Fermi surface has this special shape. Hence it is now shown that this shape is not necessary. A.

537.312.62

1806. Measurements in the transition region to superconductivity. I. W. Meissner, F. Schmeissner and H. Meissner. *Z. Phys.*, **130**, 521–8 (*No.* 4, 1951) *In German.*

There is no change in the external magnetic field produced by a current when specimens (coils and straight wires of Sn) change from the normal to the superconductive state. The observation of K. Steiner [Abstr. 976 (1950)] is confirmed, according to which the flux of a longitudinal magnetic field in a straight Sn specimen increases above its normal value before it is finally expelled, if the specimen carries a current $>$ than a certain value J_0. In these experiments the temperature is changed and the change of flux measured by an induction coil connected to an oscillograph. H. LONDON

537.312.62

1807. Measurements in the transition region to superconductivity. II. W. Meissner, F. Schmeissner and H. Meissner. *Z. Phys.*, **130**, 529–38 (*No.* 4, 1951) *In German.*

Continuation of the experiments (preceding abstract) with Sn and Hg. Individual points of the transition region are investigated by measuring the

change in flux when the longitudinal field H is reversed. The apparent maximum permeability μ reaches values >2. It is a linear function of the current J. $(\partial\mu/\partial J)_{H,T}$ varies from specimen to specimen and with Hg it differs when it is melted and re-frozen. However, the minimum current J_0 at which an increase of μ takes place is reproducible and can be expressed by $J_0 = J_g + \gamma Hd\pi$, where d is the diameter of the specimen, J_g a current and γ a numerical factor both characteristic for the element. Including the results of Abstr. 976 (1950) the values $J_g = 0{\cdot}6$; $1{\cdot}2$; $1{\cdot}7$; $0{\cdot}6$ amps and $j = 0{\cdot}67$; $0{\cdot}67$; $0{\cdot}37$; $0{\cdot}37$ are obtained for In, Sn, Hg, Tl respectively. H. LONDON

537.312.62

1808. The isotope effect in superconductivity. I. Mercury. C. A. REYNOLDS, B. SERIN AND L. B. NESBITT. *Phys. Rev.*, **84**, 691–4 (*Nov.* 15, 1951).

The critical magnetic fields of various isotopic mixtures of Hg have been measured as a function of temperature. The critical magnetic field at any temperature is found to decrease with increasing average mass, and the critical temperature also decreases with increasing mass. The relationship $M^{\frac{1}{2}}T_c = \text{const.}$, connecting the critical temperature T_c and the average mass number M, is established. Conclusions are drawn concerning the specific heats of the normal and superconducting states of the isotopes. A.

537.312.62

1809. Experiments with audiofrequencies on superconductors. B. SERIN, C. A. REYNOLDS, J. R. FELDMEIER AND M. P. GARFUNKEL. *Phys. Rev.*, **84**, 802–5 (*Nov.* 15, 1951).

Experiments are described in which alternating and direct currents are superimposed on Sn wires in the superconducting state. As the amplitude of the a.c. is increased, the average p.d. goes through a maximum and approaches an asymptotic value. The experimental curves agree with calculated curves for low frequency a.c. (< 50 c/s). However, as the frequency is increased the curves change in character. The maxima increase in height and occur at large values of the a.c. It is shown that this anomalous behaviour can be traced to the a.c. skin effect, and it is concluded that experiments of this type are not suitable for a determination of the relaxation time in the phase transition from the superconducting to the normal states. A.

537.312.62

1810. A superconducting galvanometer. A. B. PIPPARD AND G. T. PULLAN. *Proc. Camb. Phil. Soc.*, **48**, 188–96 (*Pt I*, 1952).

A superconducting tangent galvanometer suitable for the measurement of thermoelectric voltages in circuits of resistance about 10^{-7} ohm is described. The inductance has been kept low by the use of only a single turn in each of the deflecting coils, but a high sensitivity has been attained by reducing the controlling field to about $0{\cdot}01$ gauss. The theory of operation of such a galvanometer in circuits of low resistance is discussed; the actual behaviour of the instrument is in satisfactory agreement with the theory. The galvanometer will detect a current of 10^{-5} A corresponding to an e.m.f. of 10^{-12} V. A.

537.312.62

1811. Superconductivity of vanadium. A. WEXLER AND W. S. CORAK. *Phys. Rev.*, **85**, 85–90 (*Jan.* 1, 1952).

The presence of small quantities of O and N in interstitial positions in the V lattice is found to affect markedly the superconductive properties of the metal. X-ray evidence supports the supposition that these impurities set up internal strains which are known to give rise to properties very similar to those of the hard superconductors. It is suggested that these strains, which, unlike those arising from mechanical work, are not always removable by vacuum heat treatment, are responsible for the difficulties associated with the preparation of samples of the metals exhibiting a reversible B, H curve. It is shown that the sharp penetration fields for a relatively pure specimen are probably not very different from the equilibrium fields. The transition temperature of V is $5{\cdot}13°\text{K}$ $(dH_c/dT)_{T_c} = 436 \pm 20$ oersteds/deg, and the Sommerfeld $\gamma = 15 \times 10^{-4}$ cal/mole deg K^2. A.

537.312.62 : 537.311.1

Application of collective treatment of electron and ion vibrations to the theories of conductivity and superconductivity. *See Abstr.* 1777

537.312.62 : 538.23

1812. Magnetic properties of a hollow superconducting lead sphere. J. BABISKIN. *Phys. Rev.*, **85**, 104–6 (*Jan.* 1, 1952).

The magnetic hysteresis of a hollow superconducting Pb sphere at $4{\cdot}2°\text{K}$ has been studied by measuring the magnetic field distributions along the equatorial plane with Bi probes. After cooling in the absence of a magnetic field, the hollow sphere was found to be a perfect magnetic shield in the superconducting state. The magnetic field penetrated into the interior of the sphere when the magnetic field at the surface of the sphere exceeded the threshhold value. Frozen-in fields were observed upon demagnetizing the sphere from the normal state. Upon reversing the applied field, the frozen-in field could be made to vanish, so that the sphere again became a perfect magnetic shield. The magnitude of the applied field necessary to extinguish the frozen-in field was found to be the same independent of the path of approach. The internal frozen-in fields did not change over specified ranges of the applied field, so that the existence of other equilibrium superconducting states are indicated for the hollow sphere. In the intermediate and frozen-in states, 10 to 30 min were required for the magnetic field to reach an equilibrium value. A.

537.32

1813. Theory of the absolute thermoelectric power of thin metal films and wires. E. JUSTI, M. KOHLER AND G. LAUTZ. *Z. Naturforsch.*, **6a**, 544–50 (*Oct.*, 1951) *In German.*

Formulae are developed by assuming that the electron reflection at the boundaries is (*a*) completely diffuse, or (*b*) partially elastic. It is found that a variation of the absolute thermoelectric power with thickness indicates a variation of electronic mean free path with energy, and may thus give valuable information. Experimental measurements with lead and bismuth agree well with the theory; values of the

mean free paths are calculated. It is shown that the Wiedemann–Franz law should still hold.

P. M. DAVIDSON

537.32 : 537.311.33

1814. Thermo-electric measurements on semiconductors. H. K. HENISCH. Letter in *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1014 (*Nov.*, 1951).

See Abstr. 6231 (1951) 4798 (1950). The author clarifies some misunderstandings.

537.363 : 535.417

1815. An interferometric micro-electrophoresis apparatus. W. LOTMAR. *Rev. Sci. Instrum.*, **22**, 886–90 (*Dec.*, 1951).

A micro-electrophoresis apparatus based on interferometry is described. The interferometer consists of modified Jamin arrangement, using only one plate while the other is replaced by a reflecting cell at right angles to the beam, thereby doubling the sensitivity. A cell filling requires 0·4 ml of solution. No thermostat is provided. Details of the optical and electrical equipment are given. The apparatus may also be used for diffusion experiments.

A.

ELECTRIC DISCHARGES 537.52

537.523.3 : 534.15

1816. Positive sphere corona: oscillation measurements. W. FUCKS AND W. BUDDE. *Z. Naturforsch.*, **6a**, 494–504 (*Sept.*, 1951) *In German.*

A small, spherical-ended, wire electrode is used as a corona probe for following mechanical oscillations of a flat plate which is used as the plane electrode of a sphere-plane corona discharge gap. The characteristics of suitable arrangements were measured in detail and the results are displayed graphically. A contour plan for an oscillating glass plate 30 cm square is shown; the first contour is at 0·05 mm displacement.

J. D. CRAGGS

537.523.4 : 551.594.221 : 535.338–15

The near infrared spectrum of lightning. *See Abstr.* 1628

537.523.5

1817. Temperature of the positive crater in McPherson's normal graphite arc. J. EULER. *Z. angew. Phys.*, **3**, 260–3 (*No.* 7, 1951) *In German.*

From colour-temperature measurements of the positive crater it is shown that the previously observed temporal oscillations of about 2% in the radiation intensity are associated with oscillations in temperature. They are due to irregularities in the current and may be removed by a stabilizing magnetic field.

P. M. DAVIDSON

537.523.5 : 537.525.5

1818. The measurement of the temperature distribution within a wall-stabilized arc with the aid of the radioactive Hg^{203} isotope. G. ECKER. *Z. Phys.*, **130**, 585–604 (*No.* 5, 1951) *In German.*

The radial variations of particle density and thus of temp. in a Hg arc may be studied by means of a Geiger counter sensitive to the γ-rays from Hg^{203} if the arc is charged with the latter. Direct measurement is made of the total particle density from the arc in a given direction of observation for various radial positions and the true radial variation of density is deduced therefrom. Results are shown graphically in detail, for various conditions of the discharge. A typical result for a 4·1 A arc, 590 mm Hg vapour pressure gives an axial temp. of about 6 300°K which falls at a radial distance of about 8·5 mm to about 2 000°K.

J. D. CRAGGS

537.523.5 : 537.525.5

1819. Arc discharges with or without electrode spots. W. THOURET, W. WEIZEL AND P. GUNTHER. *Z. Phys.*, **130**, 621–31 (*No.* 5, 1951) *In German.*

This paper describes photographic and oscillographic investigations of the characteristics of arcs in which the cathode spots disappear at higher currents. The expts. show that in Xe the cathode spots disappear at lower currents than in Hg. The transition is sudden, and shows a hysteresis effect when the current is first increased and then decreased.

J. D. CRAGGS

537.523.5 : 537.527.5

1820. The measurement of plasma conductivity in heavily loaded arcs. H. MAECKER AND T. PETERS. *Z. Phys. Chem.*, **198**, 318–28 (*No.* 5–6, 1951) *In German.*

Gives measurements of radial temperature variations and conductivity in arcs running through water in a simple turbine arrangement. Currents varied from 112 to 1 450 A, and axial temperatures respectively from 20 000 to over 50 000°K with a discharge radius $\sim$ 1–1·2 mm. The corresponding voltage gradients varied from 93 V/cm (at 112 A) to 294 V/cm. The influence of the positive ions on the electron mobility is discussed in detail.

J. D. CRAGGS

537.523.5 : 621.3.014.31

1821. The physical mechanism of low- and high-current arcs and their relation to the welding arc. W. FINKELNBURG. *Trans Amer. Inst. Elect. Engrs*, **70**, 800–3 (*Pt I*, 1951).

The paper gives a general account of the physics of arc discharges, with special reference to the technical problems, e.g. electrode processes involved in arc welding. 9 references, mostly to the author's own work, are quoted.

J. D. CRAGGS

537.523.5 : 621.3.014.31

1822. Theory of the steady-state d.c. arc. V. HUSA. *Elektrotech. Obz.*, **40**, 130–3 (*No.* 7–10, 1951) *In Czech.*

The theory is based on Holm, Kirschstein and Koppelmann's investigation of the state of equilibrium of the current carriers in the steady-state arc [*Veroff. Siemens Konz.*, p. 64 (1934)]; the equilibrium being assumed between diffusion and electromagnetic forces acting on the electrons in the plasma of an arc burning in a gas at atmospheric pressure. The derivation of an integro-differential equation of state of the arc on this assumption is fairly simple, but the subsequent introduction of approximate and arbitrary temperature and pressure relations of the electron mobility, diffusion coefficient and field gradient is dictated by reasons of mathematical expediency, the validity of the solution so obtained (in terms of arc radius) is discussed and a relation between power per cm arc length and arc radius is found. A numerical

example for a 4 A-arc in air yields an arc diameter of 6 mm and agrees with experimental results; the validity of the results is claimed to have been verified for arcs up to 1 000 A. B. F. KRAUS (R)

537.525 : 621.387 : 621.3.015.5

1823. High-frequency gas-discharge breakdown. S. C. BROWN. *Proc. Inst. Radio Engrs*, **39**, 1493–501 (*Dec.*, 1951).

A phenomenological description of h.f. gas-discharge breakdown is given, describing the similarities and differences between these discharges and the more familiar d.c. type. H.f. discharge breakdown is controlled by the process of electron diffusion and, besides the theory of its behaviour, the physical limitations of tube size, gas pressure, and frequency for this type of breakdown are given. The particular case of hydrogen is cited. The effects of superimposing a small d.c. field and a magnetic field on the a.c. field are also discussed. A.

537.525.5 : 621.385.2 : 621.3.014.31

1824. Studies of externally heated hot cathode arcs. L. MALTER, E. O. JOHNSON AND W. M. WEBSTER. *RCA Rev.*, **12**, 415–35 (*Sept.* (I), 1951).

It is shown that in a gas discharge in cylindrical diodes with inner hot cathode, the discharge can take on a number of possible forms. At low current values the "anode-glow" mode occurs, provided the pressure exceeds some minimal value. In this case the potential in the tube is close to that of the cathode overall of the tube except for a thin film adjacent to the anode surface. The potential rises steeply in this film to above ionization potential. The light appears to come from the anode surface only. At higher current values the discharge goes over into the "ball of fire" mode in which the light comes from a definitely defined region which may be very small in volume and appear to float in space. The potential is a maximum within the ball and all excitation and ionization occur therein. The balance of the tube (except close to cathode and anode) is filled with a plasma which acts as a conductor to transport electrons from cathode to anode. At a current value equal to about half the cathode emission, the discharge goes over into a form in which ionization (and excitation) occur through all of the tube with the exception of a thin sheath around the cathode. Since this form of discharge has been studied extensively by Langmuir, it is here designated as the "Langmuir" mode. At a current equal to the cathode emission, a temperature-limited form of discharge sets in. Data and results are presented for plasma and floating potentials, electron temperature, plasma density and glow distribution for the various forms of discharge. A.

537.525.8

1825. Measurement of very high resistances by using a glow tube. A. B. PAL AND N. AHMAD. *Pakistan J. Sci. Res.*, **3**, 16–17 (*Jan.*, 1951).

The method described is suitable for measuring very high resistances of the order of several thousand megohms. A battery is used to charge a condenser through an unknown resistance. The time required to charge the condenser from zero to the breakdown voltage of a glow tube is measured by a stopwatch. The value of the unknown resistance is then calculated from the circuit constants. A.

537.525.8

1826. Study of the charge and discharge of a condenser by using a glow tube. A. B. PAL AND A. GHANI. *Pakistan J. Sci. Res.*, **3**, 18–19 (*Jan.*, 1951).

The potential difference between the plates of a condenser can be measured by using a glow tube having a stabilized breakdown voltage. The writers plotted experimental values of potential against time for several condensers during the processes of charging and discharging. The experimental curves were found to be in good agreement with the corresponding theoretical ones. A.

537.525.8

1827. The normal cathode fall and striking potential in the measurement of air humidities for vacuum drying. A. HINZPETER AND W. MEYER. *Z. angew. Phys.*, **3**, 216–18 (*No.* 6, 1951) *In German.*

Describes measurements of certain electrical characteristics of glow discharges in damp air, for pressures at 50 mm Hg and for partial pressures of water vapour equivalent to 0–30% of the total pressure. Curves relating breakdown voltage with humidity are given. J. D. CRAGGS

537.525.8

1828. A magnetic analogue of the Joshi effect. M. R. BHIDAY, V. G. BHIDE AND G. V. ASOLKAR. Letter in *Nature* [*Lond.*] **168**, 1006–7 (*Dec.* 8, 1951).

A note describing the effect of magnetic fields on ozonizer discharges, as observed by Joshi and others. Oscillographic records are given. J. D. CRAGGS

537.525.8 : 537.562 : 537.565

1829. On ambipolar space charge flow between plane electrodes. K. MÜLLER-LÜBECK. *Z. angew. Phys.*, **3**, 409–15 (*No.* 11, 1951) *In German.*

Discusses general current flow problems in a gaseous discharge, with special reference to calculation of field strength, space potential, etc. The treatment is theoretical; the results are compared with Langmuir's earlier treatment. J. D. CRAGGS

537.529

1830. Kinetic-statistical theory of dielectric breakdown in nonpolar crystals. W. R. HELLER. *Phys. Rev.*, **84**, 1130–9 (*Dec.* 15, 1951).

The steady-state Boltzmann kinetic equation for the motion of electrons under an external electric field in an idealized nonpolar insulating crystal has been set up and, after suitable approximations, solved to give the distribution function appropriate to strong fields. A criterion for dielectric breakdown is formulated in terms of crystal parameters (including the ionization probability) and applied to diamond, for which an approximate range of 75 000 to 300 000 V/cm is determined by the existing spread of mobility measurements from 4 000 to 900 cm^2/V sec. The reason for the relative insensitivity to impurities of this criterion is shown to be the weak dependence of the result on $\langle\beta\rangle N_{Av}(F=0) = 1/T$, where $\langle\beta\rangle_{Av}$ = mean trapping cross-section of impurities, defects, or any electron acceptors in cm^3/sec, $N(F=0)$ = number of such traps vacant at zero field and temperature, and $1/T$ = mean reciprocal trapping time. It is also

necessary and almost always true that N_e, the number of electron donors (shallow filled traps) in natural crystals be small relative to the atomic density of the perfect lattice. The new criterion is shown to be more critical than that of Fröhlich or von Hippel, in agreement with the suggestion of Seitz that the fluctuations from mean energy of the electrons govern the breakdown. Since, however, the electron-lattice collision probability decreases with increasing electron energy at energies above $h^2/8m\lambda_{min}^2$, where λ_{min} = shortest lattice vibration wavelength, the ionizing fluctuations governing breakdown are already present in the steady-state solution. Thus the value of the breakdown field is not sensitive to the presence of externally produced electrons, as would be true of an ordinary fluctuation phenomenon, even in uniform fields. A.

X-RAYS 537.531

537.531

1831. The wavelength of the X radiation at a depth in water irradiated by beams of X rays. J. R. GREENING AND C. W. WILSON *Brit. J. Radiol.*, **24**, 605–12 (*Nov.*, 1951).

A double-thimble ionization chamber connected to a ratio meter is used to determine quality of radiation for X-ray beams of 150 to 220 kV, and graphs are given for variation of primary, total and scattered radiation as functions of depth and distance from axis of beam. The scattered wavelength is shown to increase with depth after the first 2 cm, confirming that multiple scattering plays an important part at a depth in water. F. T. FARMER

537.531

1832. Physical measurements on a 2 MeV X-ray generator. J. L. HOWARTH, J. C. JONES and H. MILLER. *Brit. J. Radiol.*, **24**, 665–75 (*Dec.*, 1951).

Physical measurements on the X-ray beam from a 2 MeV electrostatic generator are described, with special reference to the ratio of surface ionization to peak ionization. It is concluded that most of the surface ionization arises from the air above the surface unless the beam defining system is within 30 cm from the surface. H. MILLER

537.531

1833. The output of "gassy" X-ray tubes. H. A. HUGHES. Letter in *Brit. J. Radiol.*, **24**, 691 (*Dec.*, 1951).

Comparative tests at 220 kV show a fall in output of 14% for a partially gassy tube. F. T. FARMER

537.531 : 535.312 : 539.26

1834. Collimating X-rays in beams of very small divergence and high intensity. J. A. LELY AND T. W. VAN RIJSSEL. *Philips Tech. Rev.*, **13**, 96–103 (*Oct.*, 1951).

This collimator, with which a divergence of about 5′ can be obtained, is based upon the principle of the total reflection of X-rays when they strike a polished surface at a very small angle. By means of a wedge-shaped arrangement of the reflecting planes, which can be made, for instance, from window glass, a beam of about 30′ divergence can be reduced entirely to the much smaller divergence mentioned, thereby producing a relatively intense beam. Consideration is given to the causes of the scattering occurring, which is found to arise to a smaller extent than is the case with other types of collimators. Finally an example is given of the results that can be achieved with this collimator. A.

537.531 : 535.33

1835. On the line-widths and hyperfine structure in X-ray spectra. D. CURIE. *C.R. Acad. Sci.* [*Paris*] **233**, 1351–3 (*Nov.* 26, 1951) *In French.*

A modified theory is given for the case of components whose separation is less than their widths: the usual hydrogen-like model gives a result too small by a factor of 2. A. R. STOKES

537.531 : 535.33

1836. Measurement of electron pairs for the determination of a 65-MeV X-ray spectrum. R. H. STOKES. *Phys. Rev.*, **84**, 991–3 (*Dec.* 1, 1951).

A magnetic cloud chamber has been used to observe electron pairs produced by the beam of a synchrotron operating at 65 MeV. The cross-section for pair production given by the Bethe–Heitler theory was used to obtain the X-ray energy spectrum. The observed spectrum was in agreement with that expected theoretically. Values of the quantum and energy flux are given in terms of the reading of a Victoreen thimble ionization chamber. A.

537.531 : 535.338

1837. A new non-quadrupolar radiation in the platinum *L*-spectrum. G. B. DEODHAR AND C. MANDE. Letter in *J. Sci. Indust. Res.*, **10B**, 260 (*Oct.*, 1951).

A line at λ1210 X.U. has been observed, which is apparently due to the non-quadrupole transition $L_{II}M_{II}$. $\nu/R = 753{\cdot}1$, which is somewhat lower than the value 754·8 computed from the energy levels.

537.531 : 535.543

1838. The *K* X-ray absorption structure of Cl_2 and HCl. S. T. STEPHENSON, R. KROGSTAD AND W. NELSON. *Phys. Rev.*, **84**, 806–9 (*Nov.* 15, 1951).

The fine structure on the short wavelength side of the *K* X-ray absorption edge of chlorine in Cl_2 and in HCl has been measured with a vacuum double crystal spectrometer using Geiger counter registration. Pronounced structure was obtained which agreed well with structure previously detected using lower resolution and photographic registration. However, the structure does not agree with the theory. Some reasons for the discrepancy in terms of the optical levels and the different types of binding in the two cases are discussed. A.

537.531 : 539.166 : 537.542

Measurement of continuous X-ray spectrum by scintillation counters. *See Abstr.* 1079

537.531 : 778.33

The photographic action of X-rays. *See Abstr.* 2339

537.531.08

1839. Physical significance of the röntgen for 22·5-MeV X rays. J. S. LAUGHLIN. *Brit. J. Radiol.*, **25**, 12–16 (*Jan.*, 1952).

The results are given, of a calorimetric determination [Abstr. 8766 (1951)] of the energy flux of

22·5 MeV X-rays, relative to ionization measurements. This energy flux has been related to the röntgen by using two alternative conventions. A method of obtaining the energy absorbed in water, in ergs per g/r, from these results, is outlined. The absolute number of quanta/cm²-r as a function of energy, is obtained from experimental data, and compared with calculated values. D. V. MABBS

537.531.08 : 539.166.08 : 535.371

1840. Dosimetry of X-rays and gamma-rays by radiophotoluminescence. J. H. SCHULMAN, R. J. GINTHER, C. C. KLICK, R. S. ALGER AND R. A. LEVY. *J. Appl. Phys.*, **22**, 1479–87 (*Dec.*, 1951).

The effects of high-energy radiation on the luminescence properties of solids are surveyed. Of the 4 effects considered—radiophotoluminescence, radiophotostimulation, radiothermoluminescence, and the "killing" of luminescence by X-rays or γ-rays— the first effect is shown to have advantages in principle over the others as a basis for dosimetry. The absorption, excitation, emission, sensitivity, energy dependence and stability characteristics of a radiophotoluminescent Ag-activated phosphate glass are described. It is shown that dosage measurements can be made with this material, employing a simple fluorophotometer, from 10 roentgens to a few thousand roentgens of γ-rays. By proper shielding, such a dosimeter element can be made reasonably independent of energy. The dosage indication obtained is quite stable with time and is not seriously affected by exposure of the glass to visible or ultraviolet light or to temperatures in the range of $-$ 70° to $+$ 100°C. Because of its sensitivity range and its stability over a wide range of ambient conditions, the dosimeter appears to be particularly suited for monitoring personnel that may be exposed to rather high doses of γ-rays, such as may be encountered in A-bomb explosions. A.

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533 : 621.384.61

1841. The acceleration of electrons to energies above 10^9 eV. L. RIDDIFORD. Letter in *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1013–14 (*Nov.*, 1951).

Suggestions are made for the design of an electron synchrotron incorporating a magnet of C-shaped radial cross-section facing outward (steel mass, 160 tons) and external injection at 3 MeV from a linear accelerator.

537.533.7

1842. Effect of electron diffusion on the bremsstrahlung from thin anticathodes. O. BLUNCK. *Z. Phys.*, **130**, 632–40 (*No.* 5, 1951) *In German.*

Measurements of the intensity and polarization of bremsstrahlung in the region of the critical frequency and in the direction of incidence do not agree with the Sommerfeld theory. The scattering of the electrons does not explain the result. A theory taking account of large single scattering is developed. P. M. DAVIDSON

537.533.7

1843. Energy loss of fast electrons in thin sheets. O. BLUNCK AND K. WESTPHAL. *Z. Phys.*, **130**, 641–9 (*No.* 5, 1951) *In German.*

It is shown that if the sheet is thin (i.e. if the fractional loss of energy is small) the energy loss is due mainly to the ionization. In thicker sheets the loss due to radiation is more important. The calculations are compared with experiment. P. M. DAVIDSON

537.533.7

1844. Energy distribution, drift velocity, and temperature of slow electrons in helium and argon. D. BARBIERE. *Phys. Rev.*, **84**, 653–8 (*Nov.* 15, 1951).

The energy distribution, and the drift velocity and electron temperature which are closely dependent on the distribution, were calculated for slow electrons in He and A under fields ranging from $X/p = 1$ to 4 V/cm mm. The calculations were based on the theory developed by Holstein. The diffusion cross-sections of the gases for electrons which account for the effect of elastic collisions were computed from the scattering data of Ramsauer and Kollath and of Normand. The effect of excitation collisions was taken into account by comparing the results for three representative values of excitation cross-section: $Q_{ex} = 0$ and $Q_{ex} = \infty$ which form the limiting boundaries and $Q_{ex} =$ a constant obtained from Maier–Leibnitz. Although a considerable percentage of the electrons was to be found in the excitation region for $Q_{ex} = 0$, the results for $Q_{ex} =$ constant were nearly the same as those for $Q_{ex} = \infty$. In the case of small fields, therefore, the electron energy distribution in the elastic region and related quantities may be calculated with Q_{ex} assumed infinite. A complete set of curves is given below illustrating some of the properties of the calculated quantities. The agreement between experiment and the curves obtained with the scattering data of Ramsauer and Kollath is good, while the curves obtained from the corresponding data of Normand indicate that his cross-section values are too low. A.

537.533.72

1845. [Theoretical] studies of weak electrostatic lenses: the second approximation. F. BERTEIN. *J. Phys. Radium*, **12**, 25A–31A (*Oct.*, 1951) *In French.*

The method presented previously [Abstr. 1935 (1951)] of calculating electron trajectories is placed on a more rigorous and general basis, and is extended by including in the equations higher order derivatives of the potential. The results are expressed in terms of the differences between the positions and slopes of the extrapolated asymptotic trajectories at the plane of the lens. The method is applicable to two-dimensional and axially symmetrical lenses; calculations of the aberrations of non-axial trajectories in these two types of lens are given. R. S. PEASE

537.533.72

1846. Gaussian elements of gridded lenses. M. BERNARD. *C.R. Acad. Sci.* [*Paris*] **233**, 1354–6 (*Nov.* 26, 1951) *In French.*

The expressions for the axial potential developed earlier [Abstr. 8769 (1951)] are used to deduce the Gaussian optical formulae, using an approximation

due to Glaser for the function $T = \phi'/\phi$. The theory agrees well with experiments by Knoll and Weichart.

A. H. W. BECK

537.533.72 : 621.38

1847. Space charge smoothing of microwave shot noise in electron beams. F. N. H. Robinson. *Phil. Mag.*, **43**, 51–62 (*Jan.*, 1952).

A theoretical analysis is given which takes account of both space charge interaction between electrons and the multi-valued nature of the flow due to the Maxwellian distribution of initial velocities. The theory is in agreement with the experimental results of Cutler and Quate [Abstr. 3567 (1951)] and makes possible a coherent account of shot noise at all frequencies.

A.

537.533.72 : 621.385.833

1848. Standing waves in low-energy electron beams. W. W. H. Clarke and L. Jacob. Letter in *Nature* [*Lond.*] **168**, 1120–1 (*Dec.* 29, 1951).

At energies below 30 V, the current density in a rotationally symmetrical electron beam was found to be a periodic function of distance from the beam axis, and, in the peripheral regions, an irregular function of energy and cathode temperature. These results are due to standing waves in the space-charge at the cathode.

R. S. PEASE

537.533.72 : 621.383 : 621.397.6 : 621.385.832

1849. Paraxial image formation in the "magnetic" image iconoscope. J. C. Francken and R. Dorrestein. *Philips Res. Rep.*, **6**, 323–46 (*Oct.*, 1951).

A method is described for computing paraxial rays in a cathode lens placed in a magnetic field. In order to judge the approximations made, the well-known derivation of the ray equation is given. The solutions of this equation are discussed and a physical interpretation is given. A special case, approximating the electron-optical system in the image iconoscope, is computed numerically. The electron trajectories thus found lead to a discussion of the imaging mechanism in these electron-optical systems. In some respects the mechanism appears to differ considerably from that in ordinary magnetic lenses.

A.

537.533.72 : 621.385.833

1850. An electron microscope photometer. F. A. Hamm. *Rev. Sci. Instrum.*, **22**, 895–8 (*Dec.*, 1951).

Describes an apparatus for measuring the intensity of the focused electron beam as it passes through the final viewing chamber of the R.C.A. electron microscope Model EMU. A portion of the electron rays serving to form the final image is collected by a metal probe; these electrons are passed to ground through a high resistor. The voltage developed across this dropping resistor is measured; it represents the intensity of the focused electron beam. Uses as an exposure meter in micrography and for metering the current density incident on the specimen are described

A.

537.533.72 : 621.385.833

1851. Imaging properties of a series of magnetic electron lenses. G. Liebmann and E. M. Grad. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 956–71 (*Nov.*, 1951).

The paraxial lens data and the more important first-order lens aberrations were determined for a series of symmetrical magnetic lenses of equal lens diameter D but variable air gap width S for a wide range of lens excitations. The range of gap widths covered was $S/D = 0{\cdot}2$ to $S/D = 2$. The field distribution within the lenses was measured to a high degree of accuracy with a resistance network analogue, and the lens data were then obtained through numerical trajectory tracing. The results, represented as a series of graphs, are representative of the most common magnetic electron lenses. An approximate formula for the focal length is $f \simeq 50(DS)^{1/2}V_r/(NI)^2$. A few design examples are discussed.

A.

537.533.72 : 621.385.833

1852. The symmetrical magnetic electron microscope objective lens with lowest spherical aberration. G. Liebmann. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 972–7 (*Nov.*, 1951).

Each of the investigated symmetrical magnetic lenses [preceding abstract] has an optimum value of the lens excitation parameter, for which the spherical aberration constant is smallest. Taking account of the dependence of the maximum obtainable axial field strength H_0 on the maximum field strength H_p in the pole-piece gap, one finds that there is an optimum design of electron microscope objective lens of conventional type which gives a lowest value of spherical aberration and highest resolving power. A modification of this optimum lens as adapted for practical use is described.

A.

537.533.72

1853. On the theory of the electrostatic beta-particle analyzer. V. F. T. Rogers, Jr. *Rev. Sci. Instrum.*, **22**, 723–6 (*Oct.*, 1951).

For Pt IV, see Abstr. 2333 (1946). Focusing properties of the inverse-radial potential in the spherical electrostatic analyser for charged particles having relativistic speeds are calculated by a first-order method valid for large values of $\beta = v/c$. Extending similar calculations of focusing by the logarithmic potential in the cylindrical analyser, the treatment stresses deviations from focusing properties for low-speed particles, and emphasizes analogies between the characteristics of focusing accomplished by each type of field, wherever possible. Approximate formulae are given by which the diameter of the region of least confusion may be computed for several interesting situations.

A.

537.533.72

1854. Trajectories in an axial focusing double lens spectrometer. S. C. Snowdon. *Rev. Sci. Instrum.*, **22**, 878–85 (*Dec.*, 1951).

The trajectories of an electron with zero canonical angular momentum ($p_\phi - (erA_\phi/c) = 0$) have been computed with third-order accuracy for a $1/(1 + x^2)$ axial field shape. By suitably matching the above solutions with a set of similar solutions obtained by shifting the origin, it is possible to obtain the complete zero canonical angular momentum trajectories corresponding to the double lens problem in which the axial field shape approximates rather closely one that is physically realizable. The numerical computations illustrate several typical trajectories. Design considerations are given to illustrate the utility and limitations of the theory.

A.

537.533.74

1855. A search for sudden large changes of energy of beta-rays in a cloud chamber. W. T. Davies and D. F. Shaw. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1006–12 (*Nov.*, 1951).

Measurements are presented of the changes of curvature of β-ray tracks in a cloud chamber containing air at approximately N.T.P. situated in a magnetic field of 400 gauss. These are examined for evidence of processes involving the reversible production of electrons of rest mass a small multiple of the normal value. Indications from a study of earlier investigations, that such processes might exist, are not substantiated, and the results confirm and extend those of Bleuler. It is shown that this type of cloud chamber investigation is unsuitable for obtaining useful information on inelastic scattering of fast β-particles, and that multiple scattering and observational bias are adequate to explain the anomalies previously reported. A short bibliography is appended. A.

537.533.74

1856. Scattering of 15·7-MeV electrons by nuclei. E. M. Lyman, A. O. Hanson and M. B. Scott. *Phys. Rev.*, **84**, 626–34 (*Nov.* 15, 1951).

Electrons removed from the 20-MeV betatron are focused to a 0·08-in spot about 10 ft from the betatron by a magnetic lens. The electrons impinge on thin foils at the centre of a highly evacuated scattering chamber having a diameter of 20 in. Elastically scattered electrons, selected by a $\frac{3}{8}$ in $\times 2$ in aperture, are focused by means of a 75° magnetic analyser with 3% energy resolution and are detected by coincidence Geiger counters. Corrections are applied for multiple scattering and for energy losses which remove the electrons from the range of energies accepted by the detector arrangement. The scattering cross-section for gold at 150° is found to be about 2·6 times that given by Mott's formula in the Born approximation and about one-half of that expected for the scattering by a point nucleus. This result is in good agreement with the calculations for electrons of this energy if the nuclear charge is assumed to be distributed uniformly throughout the nuclear volume. The results for the scattering from C, Al, Cu and Ag are also in agreement with the assumption of a uniformly distributed nuclear charge within the uncertainties involved in the theory and the experimental results. A.

537.533.74

1857. Measurement of multiple scattering of 15·7-MeV electrons. A. O. Hanson, L. H. Lanzl, E. M. Lyman and M. B. Scott. *Phys. Rev.*, **84**, 634–7 (*Nov.* 15, 1951).

The angular distribution of electrons scattered by thin Be and Au foils has been measured for angles where the multiple scattering is important. The $1/e$ widths of the distributions obtained with Au foils of 18·66 and 37·28 mg/cm² are 2·58° and 3·76°, respectively. These widths are about 10% narrower than those calculated from the theories of Williams or of Goudsmit and Saunderson, but are in good agreement with the calculations of Molière. The $1/e$ widths obtained with Be foils of 257 and 495 mg/cm² are 3·06° and 4·25°. These widths are about 5% smaller than those given by Molière's theory increased by $(1 + 1/Z)^{\frac{1}{2}}$ for the contribution of electron-electron collisions. The discrepancy may be qualitatively explained by the fact that the Thomas–Fermi screening used in the calculation is different from the effective screening in the Be metal. The scattering from the two Au foils was measured for larger angles where the scattering can be considered as single scattering modified by the effect of multiple scattering. The ratio of the scattering from the thick to the thin foil can be represented by the relation $2 + 95/\theta^2$ from 9° to 30°, and is in fair agreement with theoretical expressions for this ratio. A.

537.533.74

1858. Electron-electron scattering at 15·7 MeV. M. B. Scott, A. O. Hanson and E. M. Lyman. *Phys. Rev.*, **84**, 638–43 (*Nov.* 15, 1951).

The differential scattering cross-section for electron-electron scattering has been measured at relativistic energies. A focus beam of 15·7-MeV monokinetic electrons from the 22-MeV betatron was scattered by 1- and 2-mil nylon foils in a 20-in scattering chamber. The incident current was collected by a Faraday cage after it has passed through the scattering foil and was measured by a vibrating reed electrometer. The scattered beam was defined by gold-lined slits at a known angle to the incident beam. The number of scattered electrons in a given momentum interval chosen by a magnetic analyser was counted by a Geiger counter. Energy analysis of the scattered electrons made it possible to separate the nuclear scattering events from the electron scattering events. The energy of the scattered electrons was measured as a function of the scattering angle and was found to be in agreement with the laws of relativistic mechanics within an experimental accuracy of 0·4%. For the electron-electron collisions the relative scattering cross-sections agree with the Møller formula. For the electron-nuclear collisions they agree with the relativistic Mott theory (Born approximation) corrected for the radiative losses as calculated by Schwinger (3 to 8%). The experimental consistency of the cross-sections was about 4%. The absolute differential scattering cross-sections for the electron-nuclear scattering were measured at angles between 10° and 43°. The average of the absolute values was 2% lower than theory. This is probably due to systematic errors in the solid angle, and in the collection and counting efficiencies. The absolute differential scattering cross-sections for electron-electron scattering was measured at the same set of angles, which correspond to the angular interval of 70° to 150° in the centre-of-mass system. The average of these absolute cross-sections was 7% lower than theory predicts. The bulk of the 5% additional departure from theory may be due to a systematic error in the measurement of the momentum interval defined by the counter. A.

537.533.74

1859. Multiple scattering in a semi-infinite medium. J. W. Weymouth. *Phys. Rev.*, **84**, 766–75 (*Nov.* 15, 1951).

The Boltzmann equation for the multiple scattering of charged particles is solved for a semi-infinite medium by means of the Laplace transformation.

The sources are isotropic and distributed throughout the medium, corresponding to a thick layer of electron-emitting atoms. The solution is obtained as a series in spherical harmonics and is carried as far as the P^2 coefficient. In order to obtain a solution it is necessary to assume that the transport mean free path λ is not a function of energy. As a particular evaluation of the solution the flux on the surface is examined and modified to correct for the energy dependence of λ by comparing with the corresponding solution of the age diffusion equation. The resulting spectrum is compared with an experimental case of 301·3 keV photoelectrons produced in a thick Th converter. Using the experimental spectrometer resolution of 1·5% the theoretical spectrum is integrated over the window curve and a shift of the peak from the edge of the primary spectrum of 4·3 keV is obtained. Considering the errors involved this compares favourably with the experimental peak shift of 3·5 keV for a converter thickness of 25 mg/cm². A.

537.533.74

1860. Study of the multiple scattering of fast charged particles in a gas. II. Negative and positive beta-particles. G. GROETZINGER, W. HUMPHREY, JR AND F. L. RIBE. *Phys. Rev.*, **85**, 78–9 (*Jan.* 1, 1952).

For Pt I, see Abstr. 5050 (1950). The experimental study of the multiple scattering of electrons in a gas has been extended to include electrons of momenta up to 10 200 gauss-cm. The results of these measurements are compared with predictions of various theories of multiple scattering. Furthermore, a parallel investigation of the multiple scattering of positrons has been carried out over the momentum range between 2 000 and 9 000 gauss-cm. The r.m.s. angle of multiple scattering for the positrons is found to be approximately 10% less than for electrons of the same momentum. A.

537.533.74

1861. On the scattering of β-rays. M. SPIGHEL. *C.R. Acad. Sci.* [*Paris*] **233**, 1358–60 (*Nov.* 26, 1951) *In French.*

See also Abstr. 7940 (1951). Beta-rays, whose energy is defined by a 180° magnetic spectrograph, are scattered by thin gold foils. The scattering is not affected by the β-rays having traversed matter before the energy definition. J. HUGHES

537.533.74

1862. Elastic scattering of electrons. H. FESHBACH. *Phys. Rev.*, **84**, 1206–10 (*Dec.* 15, 1951).

Considers the effect of the finite size of the nucleus on the electrostatic scattering of electrons whose energy greatly exceeds their rest mass. It is shown that the phase shift for a given total electron angular momentum j, is independent of their orbital angular momentum l; that the phase shift depends on the parameter R describing the extension of the nuclear charge only through the combination pR where p is the electron momentum. If the additional assumption $pR \ll 1$ is made, it may be shown that the phase shift η_0 for $j = \frac{1}{2}$ electron is independent of the model describing the distribution of nuclear charge. For models for which the potential is finite at the origin, η_0 depends upon the model only through the volume integral of the potential over the nucleus. A.

537.533.74

1863. The scattering of slow electrons by atoms. D. LAYZER. *Phys. Rev.*, **84**, 1221–5 (*Dec.* 15, 1951).

A new approximation is proposed for calculating cross-sections for the scattering of slow electrons by atoms. Although the proposed approximation embodies the essential feature of Born's approximation it is compatible with the exclusion principle for electrons, and yields non-vanishing cross-sections for the excitation by electron impact of intersystem transitions in normal-coupling atoms. Unlike Oppenheimer's approximation it yields unambiguous results when approximate atomic wave functions are used in the calculation of excitation cross-sections, provided that these wave functions belong to a single Hermitian operator that differs from the exact Hamiltonian only through a term in the potential energy. A.

537.533.74 : 537.534.74

1864. On the theory of multiple scattering, particularly of charged particles. M. C. WANG AND E. GUTH. *Phys. Rev.*, **84**, 1092–1110 (*Dec.* 15, 1951).

The general theory of the elastic multiple scattering of particles with a strongly anisotropic scattering function is investigated without making the small-angle approximation. The rigorous transport equation is used and approximations are introduced at a later stage. The general formulation of the problem is given first. The approximations involved in the existing theories of small-angle forward scattering are discussed in some detail. The spherical harmonic method is then formulated in a manner so as to permit an explicit expression for the general nth approximation. There is an ambiguity both in (*a*) the way of defining successive approximations and in (*b*) the way of introducing approximate boundary conditions. For (*b*), the choice has been made to give the best approximation to the exact solution of the Schwarzschild–Milne problem. It is next shown that the choice of (*a*) for the spherical harmonic method leads to the same final formulas as the Gaussian quadrature method. The relation of these two methods is discussed in detail. Finally the problem of anisotropic multiple scattering is reduced to a quasi-isotropic one by using a generalized Goudsmit–Saunderson type distribution function (defined also for back scattering) as a first approximation. Three different methods are given for forward scattering (including large angles). The first method is a perturbation treatment. The second is based on the approximate delta-function character of the scattering function and employs a Fokker–Planck type development for the peaked part of the scattering function. The third is a Liouville–Neumann type of iteration applied directly to the transport equation. For back scattering the second and third of these methods also apply. In addition a special method is developed, based on the smallness of the back single scattering cross-section. The generalized Goudsmit–Saunderson distribution function is developed in powers of the thickness of the scatterer and it is shown that all 3 methods lead to the same single scattering tail. The 3 methods can be applied for any single scattering law. The screened Born–Rutherford law is introduced in some cases as an example. The

relation of the present work to previous theories is discussed. A.

537.533.74 : 537.534.74

1865. The Coulomb scattering of charged particles in nuclear emulsions. W. Bosley and H. Muirhead. *Phil. Mag.*, **43**, 63–71 (*Jan.*, 1952).

Measurements have been made on the multiple Coulomb scattering of electrons and protons in normal and diluted Ilford G5 emulsions. Empirical constants are given relating the mean angle of scattering to the product (momentum × velocity) for particles of unit charge. A.

537.533.74 : 778.3

1866. Multiple scattering and grain density measurements on electron tracks [total of 13 cm] in G-5 emulsions. I. B. McDiarmid. Letter in *Phys. Rev.*, **84**, 851–2 (*Nov.* 15, 1951).

The electrons were from pairs produced by X-rays from a 70-MeV synchrotron. A modification of Fowler's chord method [Abstr. 3235 (1950)] improved the independence of cell size of the "scattering constant." W. J. Swiatecki

537.533.74 : 778.3

1867. Multiple scattering of fast particles in photographic emulsions. L. Voyvodic and E. Pickup. *Phys. Rev.*, **85**, 91–100 (*Jan.* 1, 1952).

The multiple scattering theory of Williams is applied to photographic emulsion techniques, and the "scattering constant" K, which is commonly used in determining particle energies from mean scattering deflections, is evaluated for various experimental conditions. For fast particles K varies from 19 to 30 for scattering cell lengths between 10 and 10^4 microns of emulsion. The scattering theories of Snyder and Scott and of Molière are also compared with that of Williams. The theories of Molière and Williams agree closely for both photographic emulsions and pure substances when the Molière γ-factor, covering the transition from the classical case to the Born approximation case, is introduced into Williams's theory. For fast particles the theory of Snyder and Scott agrees with the other theories within about 1% for most cases for the mean scattering angle between tangents. A simple formula, based on the theory of Williams with the Molière γ-factor, is derived for K for photographic emulsions applying over a wide range of velocities and scattering thicknesses within about 1%. The results of a calibration experiment using electron pairs from Be^8 γ-rays seem to confirm the validity of theoretical values of K in the region $K = 22$. The mean γ-ray energy for 100 electron pairs was found to be $17{\cdot}4 \pm 0{\cdot}5$ MeV, which is in fairly good agreement with an expected mean energy of $11{\cdot}0 \pm 0{\cdot}3$ MeV. Results on the energy resolution of the scattering technique, and on the distribution of scattering deflections were also found to be in reasonable agreement with theory. Finally, comparison is made between theory and other recently published emulsion calibration experiments. A.

537.533.79

1868. The effect of a magnetic field on electrons in a periodic potential. J. M. Luttinger. *Phys. Rev.*, **84**, 814–17 (*Nov.* 15, 1951).

A theorem due to Wannier for treating the motion of electrons in a perturbed periodic field is generalized to include the effect of a slowly varying magnetic field. It is shown that the problem reduces to that of solving an effective Schrödinger equation, which is known as soon as we have solved the problem without perturbing fields. A.

537.533.8

1869. On the elimination of disturbing charges on non-conducting objects and fluorescent screens in electron beams. G. Knoerzer. *Z. Naturforsch.*, **6a**, 511–12 (*Sept.*, 1951) *In German.*

Shadow pictures of geometric objects show that the observation screen becomes negatively charged. This can be overcome and a sharpening of the image observed if a glowing W wire is placed in front of the screen but outside the beam. This acts as a source of pos. ions at a temperature less than 800°C, at which the thermionic emission is negligible. A. H. W. Beck

537.533.8

1870. The angular distribution of the secondary electrons of nickel. J. L. H. Jonker. *Philips Res. Rep.*, **6**, 372–87 (*Oct.*, 1951).

The common equipment for measuring secondary emission (disk-shaped or spherical electrode within a sphere) is not suitable to obtain data about the angular distribution of the secondary electrons. To this aim an electrode system with two concentric spheres was constructed in order to obtain a really radial retarding electrostatic field with which the behaviour of the secondary electrons with different velocities could be studied. The distribution of the secondary electrons—slow genuine secondary electrons, secondary electrons with moderate velocities, and rapid reflected electrons—was measured as a function of the angle of incidence and of the bombardment voltage of the primary electrons. The construction of the measuring-tube, the method of measuring and the results obtained are discussed. A.

537.533.8

1871. The theoretical research of temperature effect of field emission. J. Nakai. *Techn. Rep. Osaka Univ.*, **1**, 213–19 (*Oct.*, 1951).

The penetration coefficients when a free electron is incident on the surface potential barrier of pure W is calculated, assuming the surface electric field F is 10^7 or 10^8 V/cm. By using this coefficient, the energy distribution curves of the field emission currents from W cathodes have been obtained, and also the existence of the temperature effect has been theoretically proved; at 0°K the energy distribution curves lie near the Fermi level, but when $F = 10^7$ V/cm the energy distribution curves move to higher energy with increase in temperature and their magnitudes increase rapidly. However, in the case of $F = 10^8$ V/cm, their maximum points scarcely move with temperature increase, but the curves trail towards higher energy. A.

537.533.8

1872. Field-dependent secondary emission. H. Jacobs. *Phys. Rev.*, **84**, 877–84 (*Dec.* 1, 1951).

Experiments have been conducted with magnesium oxide surfaces in which high-d.c. fields were applied to the surface, while at the same time secondary emission measurements were being made. Very high

secondary emission ratios were obtained reproducibly (100 to 1 and greater). Under static conditions it was found that the ratios would increase exponentially with increasing fields. In addition, for constant fields, the ratio of liberated electrons to bombarding electrons was constant, over a wide range of bombardment energy. Measurements were made of secondary emission with a square wave field applied to the surface and time lag effects were noted. Decay time in the order of 30 μsec were measured. The rise time was found to be dependent upon field and bombarding currents. The mechanism of field-dependent secondary emission was shown to be related to an avalanche effect, triggered by the bombarding electrons. A.

537.533.8 : 621.385.15

1873. Fundamentals of secondary electron emission. M. A. Pomerantz and J. F. Marshall. *Proc. Inst. Radio Engrs*, **39**, 1367–73 (*Nov.*, 1951).

537.534

1874. Trochoidal orbits in synchrocyclotrons. U. E. Kruse, R. A. Mack and N. F. Ramsey. Note in *Rev. Sci. Instrum.*, **22**, 839–40 (*Nov.*, 1951).

Various experimental effects due to low energy protons following trochoidal orbits are described.

J. J. WILKINS

537.534 : 621.392.26 : 621.384.62

1875. Dielectric loading for waveguide linear accelerators. G. T. Flesher and G. I. Cohn. *Trans Amer. Inst. Elect. Engrs*, **70**, 887–93 (*Pt I*, 1951).

Gives a general discussion of the use of loaded waveguides for particle accelerators and then proceeds with a detailed theoretical study, embracing dielectric and guide-wall losses, of such waveguides. Finally a comparison between various disk-loaded guides and the present type is made. For the former, accelerating fields of about 3·3–3·9 MV/m/$\sqrt{}$MW are obtained and for the latter a figure of 5·2 (same units) is claimed. J. D. CRAGGS

537.534.7

1876. Electron capture and loss cross sections for protons passing through air. H. Kanner. *Phys. Rev.*, **84**, 1211–18 (*Dec.* 15, 1951).

Measurements have been made of the electron-loss cross-section σ_l and the electron-capture cross-section σ_c for H beams in air. σ_l varied from $24{\cdot}4\times10^{-17}$ cm^2 at 40·8 kV to $13{\cdot}6\times10^{-17}$ cm^2 at 325 kV. σ_c varied from $20{\cdot}8\times10^{-17}$ cm^2 at 31·4 kV to $2{\cdot}7\times10^{-17}$ cm^2 at 122 kV. In the ranges quoted, the cross-sections were well represented by the formulae $\sigma_l = (24{\cdot}54 - 0{\cdot}866E/E_0)\times10^{-17}$ cm^2, $\sigma_c = [41{\cdot}1\exp(-0{\cdot}562E/E_0)]\times10^{-17}$ cm^2, where $E_0 = 24{\cdot}8$ kV, the energy of a proton having the velocity $e^2/\hbar$. By extrapolation of the data, σ_l was found to equal σ_c at energy E_0. A.

537.534.72

1877. The field ion microscope. E. W. Müller. *Z. Phys.*, **131**, 136–42 (*No.* 1, 1951) *In German.*

By making the W point of a field electron microscope [see Abstr. 1101 (1951)] the anode instead of the cathode, increasing the potential to about 20 kV to give a field strength of about 3×10^8 V/cm and admitting H_2 into the vacuum tube, a sharply defined ion image of the W point can be obtained. The image intensity is weak but a resolution of 2–4 Å is obtainable. H. J. H. STARKS

537.534.72

1878. Suppression of spurious ions in the mass spectrometer. D. C. Hess, G. Wetherill and M. G. Inghram. Note in *Rev. Sci. Instrum.*, **22**, 838–9 (*Nov.*, 1951).

Secondary negative particles, produced at a collimating slit, move backwards and can produce tertiary ions. These may be avoided by using: a negative grid before the slit, successive deflection plates, or a strong magnetic field across the source.

T. G. PICKAVANCE

537.534.72

1879. Spherical electrostatic analyzer for measurement of nuclear reaction energies. C. P. Browne, D. S. Craig and R. M. Williamson. *Rev. Sci. Instrum.*, **22**, 952–65 (*Dec.*, 1951).

A spherical electrostatic analyser was constructed for use with the Wisconsin cylindrical analyser in accurate measurements of nuclear reaction energies. The focusing properties of such an instrument have been described by Purcell. It has the unique feature of providing a large solid angle and high resolution for a very small angular spread of the reaction products. Only a portion of the entire sphere is used. This is 90° along the path of the particles with a 60° azimuthal opening. The mean radius of the gap is 18 in and the gap spacing is $\frac{3}{16}$ in. One million volt protons may be focused with a gap voltage of 20·2 kV. The analyser is designed to fit over the cylindrical analyser and to accept particles at an angle of 135° from the bombarding beam. Alignment, focus and resolution tests show that the difficult machining of the plates has been done satisfactorily and that the analyser is properly aligned. A shutter allows small sectors of the total gap to be tested individually. A sharp focus is obtained and all sectors focus particles of the same energy for a given gap voltage. Resolution tests and calibration are made using monoenergetic protons scattered from thin targets of heavy elements. A plot of the number of particles entering the detector v. the voltage across the spherical gap gives the resolution. With 1 mm object and image apertures the measured energy resolution is 650. The measured effective solid angle with this source size and resolution is $3{\cdot}2\times10^{-3}$ steradian. A.

537.534.74

1880. Scattering of protons by alpha-particles. C. H. Braden. *Phys. Rev.*, **84**, 762–5 (*Nov.* 15, 1951).

Differential scattering cross-sections for $5{\cdot}10 \pm 0{\cdot}10$ MeV protons by He have been determined at laboratory angles from 30° to 150°. Probable errors in the cross-sections varied from 2·4% at 30° to 4·1% at 150°. The scattered protons were detected by a proportional counter. The apparatus was calibrated by a study of proton-proton scattering. A.

537.534.74

1881. Multiple scattering corrections for collimating slits. E. D. Courant. *Rev. Sci. Instrum.*, **22**, 1003–5 (*Dec.*, 1951).

When a beam of charged particles passes through a collimating aperture, the transmitted beam contains some particles which have traversed some of the

material of the diaphragm. The corrections to the effective size of the aperture are estimated. They are found to be very small for protons of energies of the order of 20 MeV but appreciable at higher energies. A.

537.534.74

1882. High energy nucleon-nucleon scattering. G. BREIT. Letter in *Phys. Rev.*, **84**, 1053–4 (*Dec.* 1, 1951).

The explanation of the observed isotropy is sought in terms of the predominance of S-wave scattering persisting to high energies due to an assumed change of state of the proton occurring in high energy processes. If, after collision, the protons are not identical they can exist in ^3S as well as ^1S states and a statistical factor 4 is gained. W. J. SWIATECKI

537.534.74 : 539.172.13

1883. The production of polarized protons and the inversion of energy levels of the $P_{\frac{1}{2}} - P_{\frac{3}{2}}$ doublet in Li^5. M. HEUSINKVELD AND G. FRIER. *Phys. Rev.*, **85**, 80–4 (*Jan.* 1, 1952).

Spin-orbit coupling in the scattering of protons by He is expected to result in polarization of the scattered proton beam. This effect has been established by performing a double scattering experiment, in the form of a polarizer-analyser arrangement, and measuring the amount of polarization. These data, used in conjunction with the phase shift analysis of the single scattering differential cross-section data, give conclusive evidence that the $P_{\frac{1}{2}}$ and $P_{\frac{3}{2}}$ energy levels in the compound nucleus of Li^{5*} are inverted. A.

537.534.75

1884. The stopping power of metals and semiconductors. Z. H. HELLER AND D. J. TENDAM. *Phys. Rev.*, **84**, 905–9 (*Dec.* 1, 1951).

Stopping power measurements have been made on Si, Ni, Cu, Ge, Zr, Rh, Ag, Sn and Au. The reduction in range of the cyclotron deuteron beam produced by samples of these materials was determined by measurement of the ionization in air at the end of the beam path. To evaluate the ionization curves a semi-empirical curve, given here, which relates extrapolated ranges with mean number ranges was computed for large straggling parameters. A range-energy curve for deuterons in Ge is given as well as approximate air and Al equivalents for Si and Ge. Range-energy curves were measured for the metals. The semiconductor results were compared with those for the metals to determine whether the difference in electrical properties produces a difference in energy loss. No difference was detected within the limits of precision of this experiment. Combining data from this experiment with those of other investigations a study of the dependence of stopping power on velocity and atomic number has been made. An empirical formula derived from these data expresses the electronic stopping power relative to Al as a function of energy and atomic number over a wide range. A formula is provided for using this relation to calculate range-energy curves in any element with $Z > 10$, and its validity is discussed. A.

537.534.75

1885. Range straggling of a nonrelativistic charged particle. H. W. LEWIS. *Phys. Rev.*, **85**, 20–3 (*Jan.* 1, 1952).

The validity of the Gaussian approximation for the range straggling, due to ionization and excitation, of a nonrelativistic charged heavy particle is investigated. Exact solutions are obtained which show that, in comparison with the usual theory: (*a*) the mean range of a particle is slightly increased; (*b*) the range distribution has a tail in the direction of shorter-than-average range; (*c*) the most probable range is slightly longer than the mean range. First a fictitious problem is solved, and then the transition to the real world is made. A.

537.534.75

1886. The range of 18-MeV protons in aluminum. E. L. HUBBARD AND K. R. MACKENZIE. *Phys. Rev.*, **85**, 107–11 (*Jan.* 1, 1952).

The circulating beam of protons in the cyclotron was multiply scattered upward by a strip of Th suspended vertically inside the dee. The energy of the scattered beam was defined by the Th strip and two slits in the magnetic field of the cyclotron. From a plot of the magnetic field along the path of the scattered protons, the mean energy was determined to be $18{\cdot}00 \pm 0{\cdot}02$ MeV. By determining the thickness of Al that stopped half the incident beam, the mean range was found to be $447{\cdot}0 \pm 0{\cdot}5$ mg/cm^2. A.

DISCHARGE TUBES . COUNTERS 537.54

537.542

1887. Relative sensitivities of windowless and end-window counters. W. L. GRAF, C. L. COMAR AND I. B. WHITNEY. *Nucleonics*, **9**, 22–7 (*Oct.*, 1951).

Relative counting sensitivities of three counters, one with a $3{\cdot}5$ mg/cm^2 mica window and the others windowless, were measured with weightless samples of β-active isotopes, ranging from C^{14} ($0{\cdot}155$ MeV β's) to UX_2 ($2{\cdot}32$ MeV). The ratio of the sensitivities of the windowless counters to that of the windowed counter, was about ten times as great in the case of the softest β-spectrum as in the case of the hardest spectrum. Self-absorption curves were taken for sources containing fixed amounts of Ca^{45} in calcium oxalate samples of different thicknesses. The curves obtained with the windowless counters showed a much sharper initial drop than in the case of the end-window counter, due to the recording in the former counters of very soft β-particles, which were filtered out in the window of the last counter. Al-absorption curves of Ca^{45}, S^{35} and C^{14} β-particles measured with one of the windowless counters are given.

L. R. SHEPHERD

537.542

1888. Self-quenching counters containing small amounts of polyatomic constituent. A. D. KRUMBEIN. *Rev. Sci. Instrum.*, **22**, 821–7 (*Nov.*, 1951).

The least amount of quenching constituent, Q_m, required to produce self-quenching action in counters filled with rare gas/polyatomic gas or vapour mixtures, was measured as a function of cathode radius and total pressure for methane, butane and ethyl acetate in He, Ne and A. It was found that the variation of Q_m with cathode radius and with total pressure was in accord with the Korff–Present theory of

quenching action for counters of this type. From these minimum amounts necessary to quench, the average least number of collisions, M_{12}, required to affect electron transfer between the rare gas ions and polyatomic molecules, was calculated for each of the 9 mixtures used. M_{12} was found to vary from about 1 collision/transfer for the ethyl acetate/neon mixture, to over 1 000 collisions/transfer for the methane/helium mixture. The order of decreasing values of M_{12} in each of the 3 rare gases used was methane, butane and ethyl acetate, while the order of decreasing values of M_{12} for any one polyatomic substance in the 3 rare gases was He, A and Ne. An attempt is made to explain these results using the theory for exchange of charge between atomic ions and molecules formulated by Kallmann and Rosen. A.

537.542

1889. The proportional counter in X-ray diffraction work. A. R. LANG. Letter in *Nature* [*Lond.*] **168,** 907–8 (*Nov.* 24, 1951).

Advantages over a Geiger counter include negligible counting losses, discrimination against unwanted wavelengths (such as harmonics), reduced background, and practically infinite life. An argon–ethylene mixture at atmospheric pressure was used.

F. R. HOLT

537.542

1890. High pressure BF_3 proportional counters. V. COCCONI TONGIORGI, S. HAYAKAWA AND M. WIDGOFF. *Rev. Sci. Instrum.*, **22,** 899–903 (*Dec.*, 1951).

Construction and filling procedures are described for neutron proportional counters filled to 101 cm Hg of enriched BF_3 + 20 cm Hg of A. Examples are given of the plateau and bias curves obtained for different values of the gas multiplication. Characteristics taken at different times after filling are practically identical, which indicates that no deterioration occurs. The effect of the electron affinity of the BF_3 is discussed, and it is shown how the counter parameters affect the survival probability of the electrons, hence the quality of the pulse size distribution. It has been verified experimentally that negative ions produced by electron attachment are present in the counter gas. A.

537.542 : 539.185

1891. A count-rate method of measuring fast neutron tissue dose. G. S. HURST, R. H. RITCHIE AND H. N. WILSON. *Rev. Sci. Instrum.*, **22,** 981–6 (*Dec.*, 1951).

The problem considered is that of measuring the fast neutron tissue dose. A special proportional counter has been designed whose response to collimated neutrons is such that the number of counts produced is approximately proportional to dose, when the neutron energy is between 0·2 MeV and 10 MeV. The response has been tested experimentally with monoergic neutrons of various energies between 365 keV and 5·2 MeV and at 14 MeV and is in good agreement with the dose curve. A.

537.542

1892. Theory of a neutron counter using proton recoils from a solid hydrogenous radiator. Y. AXNER. *Ark. Fys.*, **3,** 491–8 (*Paper* 27, 1951).

The sensitivity is calculated for a neutron counter using proton recoils from a solid hydrogenous radiator. The following assumptions have been made: the pulses from the chamber are proportional to the energy loss of the protons in the chamber gas. The range of the protons in the radiator is $R = R_0(E/E_0)^{3/2}$. The neutron-proton scattering is spherically symmetrical in the centre-of-gravity system. A.

537.542

1893. A neutron counter using proton recoils from a solid hydrogenous radiator. Y. AXNER AND B. SWENSON. *Ark. Fys.*, **3,** 499–506 (*Paper* 28, 1951).

An ionization chamber with a solid hydrogenous radiator for neutron measurements is described. The theoretical calculation of the sensitivity is experimentally verified with *d–d* neutrons. The spectrum of the recoil protons is measured with a 10-channel pulse amplitude analyser. A.

537.542

1894. An ionization chamber with boron carbide (B_4C) [electrode] layers for the measurement of thermal neutron fluxes. J. LABEYRIE, C. LALLEMANT AND J. WEILL. *J. Phys. Radium*, **12,** 32A–36A (*Oct.*, 1951) *In French.*

Describes the performance of a 10 cm-dia. ionization chamber with B_4C-coated electrodes and filled with hydrogen to 1 atmosphere pressure. A scale drawing of the chamber is given, with the electrical characteristics, i.e. sensitivity, etc. Neutron fluxes of 1 to 10^8 neutrons/sec/cm^2 can be measured. Details of the preparation of B_4C are given. J. D. CRAGGS

537.542

1895. A cloud-ion chamber. M. J. COHEN. *Rev. Sci. Instrum.*, **22,** 966–77 (*Dec.*, 1951).

A new instrument, the cloud-ion chamber, combining the functions of an ionization chamber (utilizing free electron collection) and the Wilson cloud chamber in the same gas volume has been operated successfully for a sensitive time in excess of 1 000 hours. From studies of the gas mixture with A as the major component, it is shown that an isoamyl alcohol and argon mixture is a satisfactory chamber filling under the operating conditions used. The operating characteristics of the cloud-ion chamber are described. A.

537.542

1896. An explanation of differences in counting properties among diamond specimens. G. P. FREEMAN AND H. A. VAN DER VELDEN. Letter in *Phys. Rev.*, **84,** 1050–1 (*Dec.* 1, 1951).

Use of u.v. transparency alone in selecting type II diamonds for counting is a poor criterion, but combined with examination of birefringence gives good selection method. Counting diamonds show poor birefringence, whereas non-counting type II specimens have well-defined mosaic patterns of birefringence.

G. F. J. GARLICK

537.542

1897. Removal of space change in cadmium sulphide crystals and their conduction properties under electron bombardment. R. RAMANNA AND VED PRAKASH DUGGAL. Letter in *Phys. Rev.*, **84,** 1251–2 (*Dec.* 15, 1951).

The properties of CdS single crystals as α-particle

counters are described and it is found that heating the crystals before use by means of a red-hot wire reduces space-charge effects and increases the counting rate. When bombarded with 100-kV electrons the amplification factor was found to be 10^3 and remained constant for several hours. C. A. HOGARTH

537.542

1898. Double delay line pulse shaping. T. B. NOVEY AND D. W. ENGELKEMEIR. Note in *Rev. Sci. Instrum.*, **22,** 841 (*Nov.*, 1951).

By using double delay lines the relatively slow decay pulses from NaI–Tl scintillations are altered to pulses of triangular shape with a width of 0·08 μsec. Large loss in pulse size occurs but the crystals are still more efficient than anthracene for counting of low energy γ-rays (less than 250 keV).

G. F. J. GARLICK

537.542

1899. Scintillation counters for radioactive sample measurement. H. O. ANGER. *Rev. Sci. Instrum.*, **22,** 912–14 (*Dec.*, 1951).

A γ-ray counter for liquid or solid samples is described. It uses an RCA 5819 phototube at room temperature with a Tl-activated NaI crystal in the shape of an annular ring. The γ-ray counting efficiencies of this counter for 3-milliliter samples of Fe^{59}, Co^{60} and I^{131} are about equal to the beta-particle counting efficiency of a mica-window G.M. counter when counting thin samples. When the counter is heavily shielded, the background is about 160 counts per min. The phototube operating voltage is not critical since over a wide range of operating voltage the counting efficiency and background count change only slightly. A directional γ-ray counter is also described. A.

537.542

1900. Satellite pulses from photomultipliers. T. N. K. GODFREY, F. B. HARRISON AND J. W. KEUFFEL. Letter in *Phys. Rev.*, **84,** 1248–9 (*Dec.* 15, 1951).

Satellite pulses observed during μ-meson decay measurements are investigated and are thought to arise in the photomultiplier rather than in the scintillating solution of terphenyl–toluene.

G. F. J. GARLICK

537.542

1901. Development of large cylindrical spark counters. D. E. HUDSON. Note in *Rev. Sci. Instrum.*, **22,** 849–50 (*Nov.*, 1951).

Describes a large cylindrical spark counter, $11\frac{1}{8}$ in long and with a mean "counting dia." of $2\frac{3}{4}$ in. The gap spacing between the two concentric cylinders was $137{\cdot}5\times10^{-3}$ in. The gas filling was saturated xylene vapour and argon with a total pressure of 0·5 atm. The behaviour of the counter is described and characteristic curves are given. J. D. CRAGGS

537.542 : 621.318.572

1902. The design of four-tube decade scalers. G. J. FERGUSSON AND G. H. FRASER. *Rev. Sci. Instrum.*, **22,** 937–40 (*Dec.*, 1951).

Design factors affecting the stability and speed of four-tube sixteen-minus-six decade scalers are discussed. A design is suggested in which the stability and speed are limited only by the basic scale-of-sixteen circuit used. A.

537.542 : 621.318.572

1903. A coincidence and anti-coincidence selector. G. VALLADAS. *J. Phys. Radium*, **12,** 53 A–64 A (*Oct.*, 1951) *In French.*

The system consists of 1 anticoincidence and 3 coincidence circuits which are modifications of that of Rossi. These are described and their functioning demonstrated with numerous waveforms. Considerable investigation has been carried out on the factors controlling the performance of such systems, this analysis leading to the detailed numerical calculation of circuit components. The resolving time is adjustable between 0·1 and 2·0 μsec.

A. J. KENNEDY

537.542 : 621.318.572

1904. Amplitude selectors. R. WAHL. *J. Phys. Radium*, **12,** 67 A–74 A (*Oct.*, 1951) *In French.*

An apparatus has been developed, suitable for nuclear work, which selects pulses from either 1, 4 or 10 adjacent amplitude bands, the widths of which increase with increasing amplitude, by using discriminators (passing pulses of amplitude > a set threshold) together with a blocking system based on the method of Valladas [Abstr. 1134 (1951)]. The stages of the elements of the system: discriminator, flip-flop circuit, output, are described in detail with full circuits. Its applications are widened by the use of similar elements which may be interswitched.

A. J. KENNEDY (R)

537.542

1905. Rate of drop formation in the Wilson chamber. E. BAGGE, F. BECKER AND G. BEKOW. *Z. angew. Phys.*, **3,** 201–9 (*No.* 6, 1951) *In German.*

Pressure variation, and the progress of condensation as measured by the development of blackening in successive cine-photographs of α-tracks, were recorded as a function of time for fast and slow expansions of a conventional volume-controlled cloud chamber. A theoretical treatment of the course of drop growth is given in which the variation of temperature of the growing drop is included, and the mechanism of growth at the stage when the drop dimensions are of the order of the mean free path in the gas is examined. J. G. WILSON

537.542

1906. Camera for use with Wilson cloud chamber. J. B. MCQUITTY AND R. H. FROST. *Rev. Sci. Instrum.*, **22,** 845–7 (*Nov.*, 1951).

The camera has a rotatable lens block and can be adjusted to photograph in directions up to 45° from the normal to the plane of focus. J. G. WILSON

537.543 : 621.385.2

1907. Propagation of disturbances in one-dimensional accelerated electron streams. L. D. SMULLIN. *J. Appl. Phys.*, **22,** 1496–8 (*Dec.*, 1951).

The propagation of small sinusoidal modulations in the infinite, parallel-plane diode is studied. A second-order differential equation is obtained for the a.c. convection current. Solutions are found in closed form for the cases of a drift-stream, space-charge-limited acceleration, and acceleration with an

arbitrary current density less than the space-charge-limited value. A.

537.543.5 : 621.385.3

1908. Concerning the theory and calculation of the reciprocal of the amplification factor [Durchgriff] of plane and cylindrical triodes for the case of 2-dimensional potential distributions. M. LANDSBERG. *Z. angew. Math. Phys.*, **2**, 375–93 (*Sept.*, 1951) *In German.*

This theoretical treatment of certain characteristics of triode valves is claimed to be more general than certain previous treatments by Schottky, Abraham and others, and amplification factors are deduced without the special assumptions made in the latter authors' work. J. D. CRAGGS

IONIZATION . THERMIONICS 537.56/.58

537.56

1909. The ionization in the incandescent gases of jet engines. C. KLEIN. *Ann. Télécommun.*, **6**, 287–98 (*Oct.*, 1951) *In French.*

Anomalous behaviour in the radio control of rockets leads to an examination of the thermal ionization of the ejected gases, and its effect on the propagation of radio waves. Saha's method is used to estimate the electron density in the combustion chamber, the results corresponding to effective reflection of ultra-short radio waves, but differing greatly from Goercke's experimental values. It is shown that in most cases Saha's formula is inapplicable since thermal equilibrium is not reached in the combustion chamber, and that the method proposed by Saenger, attributing the ionization to molecular collisions before the establishing of equilibrium, can yield convenient results. The mean number of collisions per electron is calculated. M. W. OVENDEN

537.56 : 551.510.535

The negative ion concentration in the lower ionosphere. *See Abstr.* 2285

537.561

1910. Ionization and dissociation by electronic impact. D. P. STEVENSON. *Disc. Faraday Soc.*, *No.* 10, 35–45 (1951).

It is shown that the mass-spectrometrically measured appearance potentials of a variety of ions in a number of different substances are mutually consistent with the assumption that there are electron-impact-induced ionization and dissociation processes $R_1 - R_2 + E \rightarrow R_1^+ + R_2 + 2\bar{E}$ such that the appearance potential of R_1, $A(R_1^+)$, is given by $A(R_1^+) = I^z(R_1) + D(R_1 - R_2)$ where $I^z(\,)$ and $D(\,)$ are the ionization potential and dissociation energy. It is further shown that a necessary condition is $I^z(R_1) < I^z(R_2)$. If $I^z(R_1) > I^z(R_2)$, then it is found that $A(R_1^+) > I^z(R_1) + D(R_1 - R_2)$ and probably the neutral product accompanying the formation of R_1^+ is not R_2 but either R_2^* or $F_1 + F_2$, where the asterisk indicates electronic excitation and the F's smaller dissociation fragments. The appearance potentials of $C_3H_6^+$, $C_3H_7^+$, $C_4H_8^+$ and $C_4H_9^+$ in the mass spectra of a number of branched alkanes have been measured. The condition, $I^z(R_1) < I^z(R_2)$, is satisfied, the appearance potentials of the ions $C_3H_7^+$ and $C_4H_9^+$ are mutually consistent and the intercombination of the appearance potentials with the appropriate thermochemical data leads to

$$D(sec.\text{-}C_3H_7\text{—H}) = 4{\cdot}0_7 \pm 0{\cdot}1;$$
$$D(tert.\text{-}C_4H_9\text{—H}) = 3{\cdot}8_8 \pm 0{\cdot}1;$$
$$I^z(sec.\text{-}C_3H_7) = 7{\cdot}4_5 \pm 0{\cdot}1;$$
$$I^z(tert.\text{-}C_4H_9) = 6{\cdot}9_0 \pm 0{\cdot}1 \text{ eV}.$$

It is thus found that the ionization potentials of the free radicals, CH_3, C_2H_5, *sec.*-C_3H_7 and *tert.*-C_4H_9, do not parallel the ionization potentials of the corresponding alkanes. In certain mass spectrometers employing wolfram cathodes, there is insufficient differential pumping between the cathode and ionization chambers, and thus the apparent appearance potentials and intensities of certain ions in the mass spectra of some substances are falsified by the back diffusion of pyrolysis products in these mass spectrometers. A.

537.561

1911. The ionization and dissociation of molecules by electron impact. C. A. MCDOWELL AND J. W. WARREN. *Disc. Faraday Soc.*, *No.* 10, 53–65 (1951).

Part I describes the results of a study of the dissociation of methane by electron impact in a mass spectrometer. The appearance potentials of the ions have been measured and a method is given which shows qualitatively whether or not an ion is formed with initial kinetic energy. Various possible dissociation processes are discussed and from the more probable of these have been derived values for the dissociation energies $D(CH_3\text{—H})$, $D(CH_2\text{—H})$, $D(CH\text{—H})$ and $D(C\text{—H})$. Part II gives the results of appearance potential measurements on the ions CH_2^+, CH^+ and C^+ produced from methyl cyanide by electron impact. Various possible dissociation processes leading to the formation of these ions are discussed. From the experimental data given in this section of the paper values for $D(CH\text{—H})$ have been deduced which are in good agreement with that obtained in Part I. A.

537.561

1912. Ionization potentials and probabilities using a mass spectrometer. R. E. FOX, W. M. HICKAM, T. KJELDAAS, JR AND D. J. GROVE. Letter in *Phys. Rev.*, **84**, 859 (*Nov.* 15, 1951).

Thermal energy spread of the electrons in the ion source is reduced to 0·1 eV and contact potential eliminated by using a variable retarding potential, and the spread normally caused by the ion accelerating field is avoided by pulsing the electron and ion fields. Comparative curves are given for argon 40^+; the probability is linear for energies < 2 eV above the ionization potential (15·75 V). T. G. PICKAVANCE

537.561

1913. Mass spectrometric studies of molecular ions in the noble gases. J. A. HORNBECK AND J. P. MOLNAR. *Phys. Rev.*, **84**, 621–5 (*Nov.* 15, 1951).

Molecular ions of the rare gases (He_2^+, Ne_2^+, A_2^+, Kr_2^+ and Xe_2^+) produced by electron impact at gas pressures from 10^{-4} to 10^{-2} mm Hg have been studied with a small mass spectrometer. The ion

intensity increased linearly with electron current and with the square of the gas pressure. The form of the ionization *v.* electron energy curves resembles closely curves of excitation probability by electron collision. The appearance potentials of the molecular ions were less than those of the atomic ions by $1{\cdot}4\ ^{+0{\cdot}7}_{-0{\cdot}2}$ V in He, $0{\cdot}7\ ^{+0{\cdot}7}_{-0{\cdot}3}$ V in Ne, $0{\cdot}7\ ^{+0{\cdot}7}_{-0{\cdot}2}$ V in A, $0{\cdot}7\ ^{+0{\cdot}7}_{-0{\cdot}3}$ V in Kr. These results can be interpreted, it is believed, only by assuming that the process of formation of the molecular ions observed in this experiment is, using helium as an example, an excitation by electron impact, $He + e + K.E. \rightarrow He^* + e$, followed by the collision process, $He^* + He \rightarrow He_2^+ + e$, where He* stands for a helium atom raised to a high-lying excited state. The results differ from those of Arnot and M'Ewen on helium particularly in that they reported the appearance potential low enough to permit metastable atoms to form molecular ions. A.

537.564

1914. Ionization by electron impact in CO, N_2, NO, and O_2. H. D. Hagstrum. *Rev. Mod. Phys.*, **23**, 185–203 (*July*, 1951).

Ionization by electron impact in diatomic gases has been studied in this work with a mass spectrometer designed to measure m/e, appearance potential and initial kinetic energy for each ion observed. Results have been obtained for the gases CO, N_2, NO and O_2 with some confirmatory work in H_2. Discussion is included of the nature and identification of dissociative ionization processes and of the retarding potential and appearance potential measurements. Values of important quantities such as the dissociation energies of CO, N_2 and NO; the sublimation energy of C; the electron affinity of O; and the excitation energy of O^- are determined again by electron impact in this work. A.

537.564

1915. Behaviour of paraffin hydrocarbons on electron impact. D. O. Schissler, S. O. Thompson and J. Turkevich. *Disc. Faraday Soc., No.* 10, 46–53 (1951).

A method of preparation of mono-, di- and tri-deutero paraffin hydrocarbons containing the deuterium on one carbon atom is described. The mass spectra are given for all the deuterated methanes, four deuterated ethanes and two deuterated propanes. A quantitative explanation is given for the mass spectra of the deuterated methanes. A.

537.565

1916. The drift velocities of molecular and atomic ions in helium, neon and argon. J. A. Hornbeck. *Phys. Rev.*, **84**, 615–20 (*Nov.* 15, 1951).

Drift velocity measurements as a function of E/p_0, the ratio of field strength to normalized gas pressure, are presented for atomic and molecular ions of He, Ne and A in their respective parent gases. Identification of the molecular ions is based upon the time resolution of the apparatus and the dependence of ion concentration on pressure, applied voltage and gas purity. Extrapolation of the low field measurements to zero field yields mobility values for atomic ions, $\mu_0(He^+) = 10{\cdot}8$ cm²/volt sec, $\mu_0(Ne^+) = 4{\cdot}4$ and $\mu_0(A^+) = 1{\cdot}63$ in good agreement with theory: Massey and Mohr compute $\mu_0(He^+) = 11$ and Holstein gives $\mu_3(Ne^+) = 4{\cdot}1$ and $\mu_0(A^+) = 1{\cdot}64$. Drift velocity data at low field for the molecular ions agree with experimental error with data of Tyndall and Powell (He), and Munson and Tyndall (Ne and A), which they assigned to atomic ions. A qualitative description in terms of ion-atom interaction forces is given for the observed field variation of the atomic ion drift velocities up to high E/p_0. A.

537.58

1917. Thermal ionization of thallium. B. N. Srivastava and V. N. Saharia. *Proc. Nat. Inst. Sci. India*, **17**, 241–6 (*July–Aug.*, 1951).

The thermal ionization of Tl vapour has been experimentally investigated by means of the vacuum graphite furnace already described [Abstr. 7982 (1951)]. Experiments have been carried out at various temperatures and pressures of Tl vapour and equilibrium concentrations of Tl^+ and electrons inside the furnace have been determined by the effusion method. From these the equilibrium constant and the energy of ionization have been calculated. The results obtained agree, within the limits of experimental error, with the theory of thermal ionization and the known spectroscopic value of the ionization potential of thallium. A.

537.583

1918. A method of measuring the interface resistance and capacitance of oxide cathodes. C. C. Eaglesfield and P. E. Douglas. *Brit. J. Appl. Phys.*, **2**, 318–20 (*Nov.*, 1951).

The interface impedance causes a feed-back that is frequency-dependent. Another frequency-dependent network is added in order to make the gain independent of frequency. When this is achieved the interface components are equal to the measuring components. The apparatus is briefly described. A.

COSMIC RAYS 537.591

537.591 : 519.21

1919. A combinatorial problem in counting cosmic rays. E. Schrödinger. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1040–1 (Nov., 1951).

The probability is computed that precisely m out of r counters be hit by at least one out of n cosmic particles, each of which has the probability $1/r$ of hitting any particular counter. The estimation of n from given r and m is discussed. A.

537.591.1

1920. Observations of the penetrating non-ionizing component of the cosmic radiation. J. C. Barton. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1042–54 (*Nov.*, 1951).

An anticoincidence arrangement of Geiger–Müller counters was used to detect that part of the non-ionizing component which is capable of penetrating 10 cm of lead. Measurements were made at sea level and at an altitude of 3 560 m. The mean absorption length of the non-ionizing particles was found to be

170 ± 5 g.cm^{-2} in air, 190 ± 35 in carbon and 400 ± 25 in lead. The secondary particles were strongly absorbed in a few cm of lead. Studies were made of the angular distribution of the secondaries and of the production of two or more secondary particles in a single process. Less than 0·5% of the non-ionizing particles were found to be associated with extensive air showers, but about 10% appeared to be produced by ionizing particles interacting in the lead above the apparatus. The angular distribution of the secondary particles produced in carbon was approximately proportional to cos θ. The nature of the non-ionizing particles is discussed, and it is concluded that the only known particles which could explain the results are high energy neutrons. On this hypothesis, their energy spectrum and intensity at the two altitudes are calculated. A.

537.591.1

1921. Intensities of heavy cosmic-ray primaries by pulse ionization chamber measurements. J. A. Van Allen. *Phys. Rev.*, **84,** 791–7 (*Nov.* 15, 1951).

The results of two rocket flights of electron collection, pulse ionization chambers above the atmosphere are summarized and discussed. It is shown that the data provide limiting information on the absolute intensities of the heavy nuclei in the primary cosmic radiation. Additional confidence in the photographic emulsion estimates of these intensities by other workers is provided by the consistency of their results with the entirely independent ionization chamber measurements. A.

537.591.1

1922. Effects of the atmosphere on the penetrating component of the cosmic radiation. E. S. Cotton and H. O. Curtis. Letter in *Phys. Rev.*, **84,** 840 (*Nov.* 15, 1951).

Comparison over 45 days of a sea-level counter telescope (rate ~ 900 hr^{-1}) with radiosonde data from neighbouring weather stations, fails to establish the correlation of sea-level intensity with local temperature in the region of meson formation proposed by Duperier. J. G. WILSON

537.591.1

1923. The significance of the absence of primary electrons for theories of the origin of the cosmic radiation. T. M. Donahue. *Phys. Rev.*, **84,** 972–80 (*Dec.* 1, 1951).

Electrons of energy above 5 BeV appear to constitute less than 0·4% of the primary cosmic radiation incident on the earth. An analysis of acceleration mechanisms reveals no distinctions can readily be made in acceleration *per se* on the basis of sign of charge or mass. The absence of high energy electrons must be explained on the basis of selective absorption. Bremsstrahlung collisions in the galaxy or the solar system and radiation caused by motion in galactic or local magnetic fields are inadequate to account for the large absorption of electrons compared with heavy particles. In collisions between energetic electrons and thermal photons losses approaching the total electron energy occur. An analysis of such collisions reveals that if cosmic rays are confined to the solar system these collisions are so frequent that no electrons should be present at energies higher than 5 BeV. The photon density is too low in interstellar space to cause a similar removal of electrons there. These results favour the solar or stellar origin theories of the cosmic radiation. A.

537.591.1

1924. Proton–meson analysis of the cosmic radiation at 3·4 kilometers. C. E. Miller, J. E. Henderson, D. S. Potter and J. Todd, Jr. *Phys. Rev.*, **84,** 981–6 (*Dec.* 1, 1951).

A magnetic cloud chamber has been used along with an appropriate arrangement of coincidence and anti-coincidence counters to photograph tracks of those charged particles at 3·4 km altitude having ranges of 0·5 to 5, 5·5 to 15 and 15 to 25 cm in Pb. An additional 2·5 cm Pb was used above the chamber to remove showers. Plotting in each case the distribution in momentum of positive and negative particles there is shown a clear resolution into protons and mesons. It is found that about twice as many protons as mesons stop in Pb at ranges between 2·5 and 7·5 cm Pb. The meson intensity (differential range intensity) is found to be $6{\cdot}1 \pm 0{\cdot}06 \times 10^{-6}$ particles per (g. sec. sterad) of air at 60 g air range and $12{\cdot}0 \pm 1{\cdot}0 \times 10^{-6}$ at 125 g air range. A.

537.591.1

1925. A deduction of the high energy spectrum of cosmic-ray primary nucleons from the observed muon spectrum. U. Haber-Schaim. *Phys. Rev.*, **84,** 1199–1202 (*Dec.* 15, 1951).

Fermi's theory of pion production is extended to treat collisions of nucleons with air nuclei. The energy distribution of the created pions and their daughter muons is approximately calculated, and is applied to correlate the observed muon spectrum in the energy range 10–100 BeV with the primary nucleon spectrum. The results and limitations of this procedure are discussed. A.

537.591.15

1926. Meson production in cosmic rays. S. Fubini and G. Wataghin. *Atti Accad. Sci. Torino I,* **85,** 317–24 (1950–51) *In Italian.*

The spectrum of mesons of photonuclear origin in extensive showers and the diffusion equation of these against decay are examined. A significant proportion of penetrating particles ($\sim 30\%$) at sea level may be of photonuclear origin, but at 50 cm Hg the proportion is negligible. J. G. WILSON

537.591.15

1927. Maxima in the transition curve of cosmic ray showers. H. Thurn and W. Bothe. *Z. Naturforsch.*, **6a,** 576–91 (*Nov.*, 1951) *In German.*

Using an arrangement of crossed counters with an anticoincidence screen, the properties of the showers at the 2nd max. (16 cm Pb) and the 3rd max. (26 cm Pb) have been investigated. Their absorption length is about 100 g/cm^2. The 2nd max. showers are produced by charged particles (μ-mesons?) and consist of a mixture of neutral and charged particles. The 3rd max. showers are produced by a neutral radiation (neutral μ-mesons?) and contain 2 charged particles and possibly a number of neutral particles. The position of the 3rd max. depends on the reduced sea-level pressure, shifting 1·6 cm Pb towards smaller thicknesses for an increase of 1 cm

Hg. A filter placed 1 metre above the apparatus has an influence on the position of the 3rd max.

E. P. GEORGE

537.591.15

1928. Penetrating showers in copper. P. C. BHATTACHARYA. Letter in *Phys. Rev.*, **84**, 1052 (*Dec.* 1, 1951).

The transition curves for "local" and "extensive" penetrating showers is established in copper up to 300 g cm^{-2} and shows no unusual features. One local shower is observed for every 6 000 mesons falling in the normal solid angle of collection, a result referring to (1 + 2 + 2) fold coincidences through 20 cm Pb at Ottawa. J. G. WILSON

537.591.3

1929. Primary specific ionization of cosmic rays in hydrogen. M. H. SHAMOS AND I. HUDES. Letter in *Phys. Rev.*, **84**, 1056 (*Dec.* 1, 1951).

The efficiency of a counter telescope containing 20 cm Pb and a counter of low efficiency, filled to 2 cm H_2, was measured at sea level and under 13 800 g cm^{-2} of rock. The ratio of efficiencies was measured to be (1·17 ± 0·3), while the calculated value based on the sea-level μ-meson spectrum and the purely ionization (Halpern–Hall) absorption in rock is 1·18. J. G. WILSON

537.591.5

1930. East-West asymmetry of the total cosmic radiation at Montreal (sea level). G. LABONTÉ. *Ann. Acfas*, **17**, 71–5 (1951) *In French.*

Measurements at 30° and 45° zenith angle with a threefold counter telescope confirm that there is no significant E–W effect at sea level in 57° geomagnetic latitude. J. G. WILSON

537.591.5

1931. Zenithal distribution of low energy mesons. A. G. VOISIN. Letter in *Phys. Rev.*, **84**, 850 (*Nov.* 15, 1951).

The zenith-angle variation at sea level of meson intensity in the ranges 300–410 MeV/c, 410–510 MeV/c is measured using a counter telescope with anti-coincidence under Pb absorbers. J. G. WILSON

537.591.5

1932. A search for a diurnal variation in the rate of star formation. G. W. ANDERSON AND J. E. NAUGLE. Letter in *Phys. Rev.*, **84**, 864 (*Nov.* 15, 1951).

Star formation (rate *v.* number of prongs) in Ilford G5 emulsions was compared in flights of 7·4 hr at 18 g cm^{-2} in daytime and 14·9 hr at 25 g cm^{-2} at night in 54° geomagnetic latitude. Using a Gross transformation for the difference of depth of exposure, no significant difference between day and night is found. J. G. WILSON

537.591.5

1933. The relative intensity of cosmic-rays at sea level at geomagnetic latitudes 56·8 and 83·0. D. C. ROSE, W. HEIKKILA AND E. FORD. *Phys. Rev.*, **84**, 986–90 (*Dec.* 1, 1951).

During the summer of 1950 two cosmic-ray counter telescopes were exchanged between Ottawa (geomagnetic latitude 56·8°N) and Resolute (geomagnetic latitude 83·0°N) in such a way that an accurate comparison of vertical intensities could be made. The telescopes were operated under almost identical conditions for about three weeks; then they were exchanged, the Ottawa telescope being flown to Resolute and the equipment there returned to Ottawa. Corrections were made for barometer and differences in altitude by reducing all counting rates to that at 1 000 mb pressure using known barometer coefficients. Corrections were made for differences in the atmospheric temperature by integrating numerically through the mean atmosphere at each station to get the probability of meson decay between production levels and the 1 000 mb layer. When all corrections were made there remained a difference in intensity of 1·76 ± 0·75%. No difference would be expected with the absorbers used (14½ in of Pb) at latitudes so high above the "knee." Arguments are presented to show that the difference is probably due to mesons produced by a group of field sensitive primaries and scattered into the telescope. This group of primaries could come from directions with large zenith angles, which would be allowed at Resolute but excluded at Ottawa. A.

537.591.5

1934. Absence of a detectable diurnal variation in the frequency of heavy primaries and nuclear disintegrations at 80 000 feet. G. W. MCCLURE AND M. A. POMERANTZ. Letter in *Phys. Rev.*, **84**, 1252–3 (*Dec.* 15, 1951).

An ionization chamber internally calibrated with Po α-particles and flown to 80 000 ft in a heated gondola near 55° geomagnetic latitude shows no detectable day–night variation which might be attributed to heavy nuclei. If these showed a large (~ 50%) night deficiency the burst rate would be reduced by about 20%: this is not observed and is outside the uncertainties of the measurement.

J. G. WILSON

537.591.8

1935. Nuclear disintegrations caused by fast cosmic-ray neutrons in photographic emulsions. J. PERNEGR. Letter in *Nature* [*Lond.*] **168**, 1005 (*Dec.* 8, 1951).

Observations on stars and single tracks lead to the conclusion that both are produced by neutrons in glancing collisions with emulsion nuclei.

E. P. GEORGE

537.591.8

1936. Transition effect of the star-producing radiation. L. TOMÁŠKOVÁ. Letter in *Nature* [*Lond.*] **168**, 1005 (*Dec.* 8, 1951).

A 5% increase in star-frequency was observed at 2 cm Pb in emulsions exposed at 2 640 m for 45 days.

E. P. GEORGE

537.591.8

1937. Nuclear interactions of cosmic rays in a silver chloride crystal. F. C. BROWN AND J. C. STREET. *Phys. Rev.*, **84**, 1183–9 (*Dec.* 15, 1951).

A disk of $AgCl_2$, cut from a large crystal grown by slowly cooling the melt, was operated as an ionization detector at sea level and at Climax, Colorado, elevation 11 200 ft. Calibration was achieved by testing the response of the crystal to single cosmic-ray particles ionizing near minimum. By means of a Geiger counter coincidence system stars produced in the crystal by ionizing particles (protons) were

separated from those produced by non-ionizing particles. A pulse-height distribution is plotted for the larger pulses and is in approximate agreement with star data from photographic emulsions for energy releases in the crystal of greater than 80 MeV. Electron showers and slow protons which stop in the crystal are shown to contribute to the rates below this energy. An apparent absorption thickness in air of 114 ± 5 g/cm^2 is obtained for the ionizing star-producing radiation between Climax and sea level. By assuming a geometrical cross-section for interaction in the crystal, the intensity of energetic protons at Climax is estimated to be approximately 10% of the hard component. A.

537.591.8

1938. Observations on some high energy cosmic-ray collisions in photographic emulsions. E. PICKUP AND L. VOYVODIC. *Phys. Rev.*, **84**, 1190–8 (*Dec.* 15, 1951).

A brief account is given of some high-energy disintegrations initiated in photographic emulsions by primary cosmic-ray particles at about 90 000 ft above sea level. In particular, 6 events which show only relativistic or near relativistic fragments and a typical forward cone of shower particles are described in detail. The angular distribution of the shower particles is, in some of these cases, consistent with them, being due to the multiple production of mesons in a single interaction between an incoming nucleon and a H nucleus, or a nucleon on the edge of a heavier nucleus, according to the mechanism of Fermi's recent theory. One of these events has thus been interpreted as a collision between an incoming Li nucleus with an energy of about 2×10^{12} eV per nucleon and a H nucleus in the emulsion. A.

537.591.8

1939. The solution of the Janossy *G*-equation. H. MESSEL AND G. W. GARDNER. Letter in *Phys. Rev.*, **84**, 1256 (*Dec.* 15, 1951).

This is given without using Janossy's generating function [see Abstr. 4336 (1950)]. W. J. SWIATECKI

537.591.8

1940. The distribution of multiplicities of neutrons produced by cosmic-ray μ-mesons captured in lead. M. F. CROUCH AND R. D. SARD. *Phys. Rev.*, **85**, 120–8 (*Jan.* 1, 1952).

The nature of the μ-meson capture process in Pb has been investigated by studying the number of neutrons emitted by the excited nucleus. Working under 2 000 g.cm^{-2} of clay and limestone and a 144 g.cm^{-2} Pb filter, events were studied in which a single charged particle penetrated a triple coincidence telescope and stopped in an 86 g.cm^{-2} Pb absorber, with one or more delayed coincident neutron counts from an array of ten $B^{10}F_3$ counters in a paraffin moderator placed below the absorber. Events in which more than one G.M. tube in any coincidence tray was discharged were rejected. A large paraffin barrier was interposed between the absorber and filter to reduce the sensitivity to neutrons originating above the absorber. The neutron detecting geometry is thought to have had an efficiency sensibly independent of neutron energy up to about 10 MeV. On the basis of 327 delayed neutron coincidences, the mean multiplicity of disintegration neutrons per stopped negative μ-meson was found to be $2{\cdot}16 \pm 0{\cdot}15$ with $\pm$ 10% additional error due to the uncertainty in the strength of the standard neutron source used to determine neutron detecting efficiency. The mean squared multiplicity was found to be $5{\cdot}2 \pm 1{\cdot}9$ on the basis of 3 double-neutron coincidences. On the evaporation model the expected mean multiplicity for 100 MeV excitation energy is about 6, while a calculation based on the $\mu^- + P \rightarrow N + \nu$ hypothesis, using the distribution of excitation energy calculated on the free-particle model, and Weisskopf's statistical theory of the nucleon evaporation process, leads to an expected mean multiplicity of 0·95. A.

MAGNETISM 538

538.082.102

1941. Description of an apparatus for measuring diamagnetic susceptibilities. W. MUND AND M. VAN MEERSCHE. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 549–56 (*No.* 7, 1951) *In French.*

The magnetic balance is a variant of the translation balance, the compensating force being the small horizontal component of the force of gravity. The samples used weighed $< 0{\cdot}05$ g and the sensitivity is as high as that of other types of balance. Results of measurements on some organic substances are given. E. P. WOHLFARTH

538.114

1942. Ferromagnetic resonance and the internal field in ferromagnetic materials. J. R. MACDONALD. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 968–83 (*Nov.*, 1951).

A classical treatment of the domain energy terms of a homogeneous ferromagnetic solid leads to a formula for the internal field contributions from these terms. With this result, modifications in the resonance condition of ferromagnetic resonance arising from self energy, exchange energy, magnetocrystalline anisotropy and applied or intrinsic stress are obtained and are applied to various crystalline anisotropy and stress conditions of interest in ferromagnetic resonance experiments. Finally, the bearing of the results on the anomalous *g*-values obtained in resonance experiments is considered. A.

538.114

1943. Application of the Bethe–Weiss method to the theory of antiferromagnetism. Y.-Y. LI. *Phys. Rev.*, **84**, 721–30 (*Nov.* 15, 1951).

The P. R. Weiss method developed in the theory of ferromagnetism is applied to antiferromagnetism by introducing sublattices. Atomic lattices (spin $\frac{1}{2}$ per atom) with negative Heisenberg exchange coupling J between the nearest neighbours are investigated. It has been found that two-dimensional lattices cannot sustain antiferromagnetic order. The Curie temperatures of the simple cubic and b.c.c. structure are, respectively, $2{\cdot}004|J|/k$ and $3{\cdot}18|J|/k$. That the f.c.c. lattice cannot be ordered by the interactions among the nearest neighbours is deduced from the disorder of a quadratic layer and the ineffectiveness of the interactions between layers in a f.c.c. lattice in producing order. This helps to understand why the ordering pattern of spins in Mn ions in MnO should

be such as observed by Shull. Curves are obtained for reciprocal susceptibility and for short-range order *v.* temperature above the Curie point T_c. The experimental formula $\chi = \text{const.}/(T + \theta)$ is compared with the present theory. For the simple cubic and b.c.c. lattice $\theta = 1{\cdot}5T_c$ and $1{\cdot}25T_c$ respectively are obtained if the theoretical curve is extrapolated from extremely high temperatures, and θ is slightly higher than these values if extrapolation is from the temperature range at which experimental readings are taken. This compares more favourably with the experimental data than the prediction $\theta = T_c$ of the molecular field theory. The general validity of the theory and its failure in the range of low temperatures are discussed. A.

538.122

1944. Magnetic field and torque in the case of a magnetized ellipsoid in a [magnetically] permeable medium and an applied field. H. Diesselhorst. *Ann. Phys.* [*Lpz.*] **9,** 316–24 (*No.* 6–7, 1951) *In German.*

Formulae are derived for the potential inside and outside a magnetized ellipsoid acted on by a uniform magnetic field in a liquid medium of given permeability. The torque on the ellipsoid is calculated from the formula given by Döring [see Abstr. 5942 (1950)]. Corresponding formulae apply to electrets in an electric field. A. E. De Barr

538.122

1945. On the force and torque on magnetized bodies in a magnetic field. W. Döring. *Ann. Phys.* [*Lpz.*] **9,** 363–72 (*No.* 6–7, 1951) *In German.*

Formulae are derived, without the use of the Maxwell stress tensor, for the force and torque produced by a magnetic field on a magnetized body surrounded by a fluid medium of permeability μ. It is shown that the Maxwell stress tensor gives the same result in the case considered, but that the Kneissler tensor does not lead to the correct result. The torque on a homogeneously magnetized ellipsoid in a uniform magnetic field is calculated.

A. E. De Barr

538.22

1946. Magnetic study of some inorganic compounds of arsenic, antimony and bismuth. M. Prasad, C. R. Kanekar and L. N. Mulay. *J. Chem. Phys.,* **19,** 1440–4 (*Dec.,* 1951).

In the graphs of the molecular susceptibilities χ_m of some salts of As, Sb and Bi, containing the same anions against Z, the total number of electrons in them are non-linear in each case if all the salts are taken into consideration. These graphs are, however, similar in nature and bring out the family relationship of these cations. Ikenmeyer's relation is seen to hold true only in the case of the halides of As, Sb and Bi and the salts of these cations in combination with the same anion. The linear relation observed between χ_m of the salts of As, Sb and Bi containing the same anion and the number of electrons N in the cations has been used to evaluate the susceptibilities of the cations and the anions in combination with them. The significance of this relation and its advantages over other methods of determining ionic susceptibilities have been discussed. The experimental susceptibilities of these cations have been compared with the theoretical values calculated by Slater's and Angus's methods and have been used to evaluate the radii of the cations. A.

538.221

1947. The effects of impurities on initial permeability. M. Kersten. *Z. phys. Chem.,* **198,** 89–106 (*No.* 1–4, 1951) *In German.*

Recent developments in the theory of ferromagnetic hysteresis are applied to a discussion of the initial permeability of pure and slightly impure ferromagnetic substances. The fact that the permeability of pure Fe is much more sensitive to impurities than that of Ni–Fe alloys with $> 40\%$ Ni is interpreted. A formula giving correctly the observed maximum initial permeability values of Ni–Fe alloys is derived.

E. P. Wohlfarth

538.221

1948. Theory of the coercive force and magnetic susceptibility of a ferromagnetic powder (dependence on the density of packing). E. Kondorskiĭ. *Dokl. Akad. Nauk SSSR,* **80,** 197–200 (*No.* 2, 1951) *In Russian.*

538.221

1949. Temperature dependency of half line width in ferrite. T. Okamura and Y. Torizuka. Letter in *Nature* [*Lond.*] **168,** 872 (*Nov.* 17, 1951).

Reports measurements for Mg and Cu ferrites between −195°c and the Curie point. The line width decreases monotonically with increasing temperature and vanishes suddenly just above the Curie point, in contrast to the behaviour of ferromagnetic metals. E. P. Wohlfarth

538.221

1950. Curie temperature of nickel-zinc ferrites as a function of the nickel-zinc ratio. K. F. Niessen. *Physica,* **17,** 1033–49 (*Nov.–Dec.,* 1951).

In a series of mixed crystals of nickel ferrite (or any other ferromagnetic ferrite $Me^{2+}Fe_2O_4$) and zinc ferrite, the ratio of the Curie temperature to that of the zinc-free ferrite, can be calculated by means of a generalization of Néel's extension of the Weiss theory to ferrites. In this generalization the interactions of all magnetic ions are taken into account. The dependence of the Curie temperature on composition leads to the prediction that zinc ferrite is antiferromagnetic. A.

538.221 : 539.382

1951. Anomalous variation of Young's modulus of antiferromagnetics at the Néel point. R. Street and B. Lewis. Letter in *Nature* [*Lond.*] **168,** 1036–7 (*Dec.* 15, 1951).

Measurements by a dynamic method indicate that the Young's modulus of NiO and CoO increases by 75 and 150% respectively on heating through the antiferromagnetic transition temperature (234 and 16°c respectively). A tentative explanation is given.

E. P. Wohlfarth

538.221 : 621.318.1.042.15

1952. Relationship between hysteresis, creep and Richter after-effect. R. Feldtkeller, H. Wilde and G. Hoffman. *Z. angew. Phys.,* **3,** 401–9 (*No.* 11, 1951) *In German.*

A comparison is made of the components of the

complex permeability of 3 samples of Si–Fe (4% Si) transformer laminations from the same source but differing in the magnitude of their Richter after-effects. Corresponding differences in the increase in permeability with field strength were observed; the magnitudes of the harmonics and combination tones were much smaller, although some remarkable differences were noted in the creep of the amplitude of these overtones. A description is given of apparatus comprising an a.c. bridge and frequency analyser for measurements on complex permeability. See also Abstr. 3632 (1951). H. J. H. STARKS

538.222

1953. The sextet ground-level in diluted iron alum. P. H. E. MEIJER. *Physica*, **17**, 899–912 (*Oct.*, 1951).

The assumption that the splitting of the ^6S ground-level in iron alum is due to a crystal field of cubic symmetry is unable to bring the specific heat measurements and the paramagnetic resonance data into agreement with each other. This discrepancy can be removed in a natural way by introducing an additional field of trigonal symmetry. In particular the resonance pattern observed in two sets of experiments recently performed in Leiden for two different directions of the constant magnetic field can be explained in a rather satisfactory way. In the absence of a magnetic field the ground-level has an overall splitting of $0{\cdot}15\ \text{cm}^{-1}$, which is about the same as was supposed before, but there are now three doubly degenerated levels instead of two coincident and one separate level. One has still the choice between four possibilities. A.

538.222

1954. Paramagnetic resonance in liquids. M. TINKHAM, R. WEINSTEIN AND F. KIP. Letter in *Phys. Rev.*, **84**, 848–9 (*Nov.* 15, 1951).

The h.f.s. was observed in dilute solutions containing Mn^{++} ions. All observable structure is explained by the simple Hamiltonian (with usual symbols): $\mathscr{H} = g\beta H \,.\, S + AI \,.\, S$, with $g = 2{\cdot}001 \pm 0{\cdot}001$ and $A = 95$ gauss. The line width is discussed. L. PINCHERLE

538.222

1955. The magnetic susceptibility of uranium. C. J. KRIESSMAN, JR AND T. R. MCGUIRE. *Phys. Rev.*, **85**, 71–2 (*Jan.* 1, 1952).

Using a body force method the magnetic susceptibility of U has been found to increase from $1{\cdot}66\times10^{-6}$ e.m.u. per g at -195°C to $2{\cdot}16\times10^{-6}$ e.m.u. per g at 1 120°C. The room temperature value is $1{\cdot}72\times10^{-6}$ e.m.u. per g. Two abrupt increases in the susceptibility were observed at 698°C and 808°C. A.

538.222 : 536.48

1956. The magnetic susceptibility of zinc at liquid nitrogen temperatures. J. W. MCCLURE AND J. A. MARCUS. *Phys. Rev.*, **84**, 787–8 (*Nov.* 15, 1951).

The magnetic susceptibility of Zn parallel to the hexagonal axis, χ_3, has been observed to be field-dependent up to 85°K. The behaviour of χ_3 at liquid N temperatures somewhat resembles the de Haas–van Alphen effect with the amplitude of oscillation sharply decreased and the maxima and minima displaced in field strength. The value about which χ_3 oscillates appears to be a constant approximatel yequal to $-0{\cdot}180\times10^{-6}$ up to at least 63°K. Addition of 0·016% Cu does not significantly change the results. A.

538.222 : 541.67

1957. Magnetochemistry of the heaviest elements. V. Uranium tetrafluoride-thorium tetrafluoride solid solutions. J. K. DAWSON. *J. Chem. Soc.* (1951) 2889–92 (*Nov.*).

For Pt IV, see Abstr. 8845 (1951). The magnetic susceptibilities of solid solutions of U and Th tetrafluoride have been measured over the temperature range 90–350°K, and at all dilutions the susceptibility of the U(IV) ion obeys the Weiss–Curie law. At infinite dilution the extrapolated susceptibility and the magnetic moment of U(IV) are close to the theoretical values predicted for a $5f^2$ electron configuration with the *j–j* type of coupling. This is in contrast to the corresponding oxide system in which urania is diluted with thoria, since the susceptibility and the magnetic moment of U(IV) at infinite dilution in that case correspond tp theoretical values expected for a $6d^2$ electron configuration. A.

538.224

1958. Magnetic susceptibility of grey tin. G. BUSCH AND E. MOOSER. *Z. phys. Chem.*, **198**, 23–9 (*No.* 1–4, 1951) *In German.*

Measurements of the diamagnetic susceptibility of pure and slightly impure (0·1% Mg) grey tin specimens are described (80°K–R.T.) The results are analysed into 3 contributions: the temperature independent diamagnetism of Sn atoms ($\chi = -0{\cdot}265\times10^{-6}$), the exponentially temperature dependent diamagnetism of the free electrons activated into the conduction band (activation energy 0·1 eV), and the exponentially temperature dependent paramagnetism of Mg ions acting as acceptors (activation energy $1{\cdot}4\times10^{-3}$ eV). E. P. WOHLFARTH

538.224

1959. Diamagnetism of some isoelectronic compounds. L. N. MULAY. *Proc. Indian Acad. Sci. A*, **34**, 245–9 (*Oct.*, 1951).

The magnetic susceptibilities of (*a*) isoelectronic compounds containing the same number of atoms such as (i) $SbCl_3$, TlCNO; (ii) Bi_2O_3, $SnBr_4$ and (*b*) of isoelectronic compounds containing different number of atoms, such as (i) phenol, aniline, toluene; and (ii) *p*-hydroxyphenyl, *p*-aminophenyl, *p*-tolyl arsinic acids were measured on a new type of Gouy's balance in which a modified Mettler balance has been employed. The essential modifications have been indicated. A.

538.23

1960. A new hysteresis effect in magnetism. W. H. AARTS. *S. Afr. J. Sci.*, **48**, 124–6 (*Nov.*, 1951).

The discovery of a new hysteresis effect associated with the inverse Wiedemann effect is reported. The experimental method was to pass a current through a cylindrical ferromagnetic specimen while under torsion, and measure the longitudinal magnetization. Koboyashi found with iron and steel a decrease of

longitudinal magnetization when the current was reduced at constant twist. This paper reports the same effect in the case of iron, but in the cases of steel and nickel an increase has been found when the current is sufficiently large. A suspended needle magnetometer was used and the investigation showed that the usual ballistic galvanometer method of examining the Wiedemann effect can lead to erroneous results. A.

538.23

1961. A new point of view on magnetic losses in anisotropic bars of ferrite at ultra-high frequencies. H. G. Beljers, W. J. van de Lindt and J. J. Went. Letter in *J. Appl. Phys.*, **22,** 1506 (*Dec.*, 1951).

The magnetic losses at frequencies between 100 and 10 000 Mc/s may be reduced by up to 10% by applying a relatively small axial d.c. field. The conditions under which this reduction is appreciable are indicated and the phenomenon is explained qualitatively. E. P. WOHLFARTH

538.23

1962. A Ferromagnetic hysteresis potentiometer. H. Aspden. *Rev. Sci. Instrum.*, **22,** 869–71 (*Dec.*, 1951).

The potentiometer embodies the principle of the normal fluxmeter method of measuring hysteresis loss but, while retaining the accuracy, enables the measurement to be made in a fraction of a minute. The potentiometer incorporates a number of tappings which are connected to individual contact studs so that by rotating a contact arm the current supplied to a magnetizing circuit can be varied in a cyclical manner between two limiting values. There are intermediate positions of the arm which correspond to intermediate values of current and these values differ by fixed amounts from one cycle of magnetization to the next. The contact arm also forms part of a stud switch so that a search coil can be disconnected from a fluxmeter over the part in each cycle over which the current changes between the intermediate and one of the limiting values. In this way a complete rotation of the arm is made to take a specimen through twelve cycles of magnetization and since the intermediate current values are evenly distributed over a complete cycle the fluxmeter registers a deflection which can be related to the hysteresis loss. A.

538.23

1963. Magnetization hysteresis loop tracer for long specimens of extremely small cross section. E. C. Crittenden, Jr, A. A. Hudimac and R. I. Strough. *Rev. Sci. Instrum.*, **22,** 872–7 (*Dec.*, 1951).

An instrument for measurement of the low frequency magnetic properties of thin layers is described. The difference signal from two opposed pick-up coils, one of which contains the sample, is amplified, integrated and amplified again to cause the vertical deflection of a cathode-ray oscillograph to be proportional to the intensity of magnetization of the specimen. A signal is applied to the horizontal deflecting plates of the oscillograph to cause it to represent the applied magnetizing field in the region of the pick-up coils. A large reduction in low frequency noise in the difference signal preamplifier is accomplished by use of a circuit similar to electrometer tube circuits. Noise introduced through integration of sharp peaked signals is reduced by use of first and third harmonic components in the magnetizing field current. A signal equal to noise is produced by a flux change of 75×10^{-6} Maxwell. A.

538.23 : 621.396.616 : 621.317.43 : 621.3.017.32

1964. On the magnetic hysteresis losses in magnetostriction vibration. Y. Kikuchi and H. Shimizu. *Sci. Rep. Res. Inst. Tohoku Univ. B,* **1–2,** 365–79 (*March*, 1951).

In powerful magnetostriction vibrations, the very large mechanical strain alternates in the material of the vibrator with the superposition of the very large alternating magnetization under the state of existence of the bias magnetization. The magnetic and elastic hysteresis losses arising present new problems. The following result was derived theoretically: in magnetostriction vibration, the magnetic hysteresis loss is determined uniquely by the alternating amplitude of magnetization only, and is independent of the superposed alternating mechanical strain of the vibrator; the elastic hysteresis loss is also determined by the amplitude of mechanical strain, and is independent of the pulsation of the magnetization. The symmetrical and unsymmetrical magnetic hysteresis losses of nickel were measured under various tensions. It is shown that the symmetrical hysteresis loss increases considerably with the tension, but the unsymmetrical hysteresis loss does not vary so largely with tension in the range of positive magnetization which is the operating range of almost all magnetostriction vibrators. The variations of the losses are within only 10–20%. It may be concluded that the magnetic hysteresis loss in the magnetostriction vibration is equal to that in the state of no stress where the amplitude of magnetization is equal to that of the actual state. A.

538.24

1965. The magnetization process in ferrites. H. P. J. Wijn and J. J. Went. *Physica*, **17,** 976–92 (*Nov.–Dec.*, 1951).

The initial magnetization curve of ferrites has been measured as a function of frequency up to 2 Mc/s. It has been found that the magnetization of sintered ceramic ferrites with a high permeability is brought about by at least two processes, one of which, in the frequency range covered, is independent of frequency and determines the initial permeability. The other process has a relaxation frequency of about 200 kc/s and is responsible for the irreversible processes during magnetization. From measurements on samples of sintered ferrites fired at different temperatures it has been concluded that the frequency-dependent magnetization is caused by irreversible Bloch-wall displacements, whilst the initial permeability is caused by a reversible rotation of the magnetization in Weiss domains in the direction of the external magnetic field (in contrast to what is believed to be the case in cast ferromagnetic metals). A discussion shows that neither eddy current effects nor any inertia effects so far known are responsible for the relaxation frequency of the Bloch wall at about 200 kc/s. A.

538.244.2 : 621.3.013 : 621.318.423

1966. Similarity relations in iron-free coils intended for the production of very intense magnetic fields. F. GAUME. *J. Rech. Cent. Nat. Rech. Sci.*, **3**, 269–80 (*No.* 14, 1951) *In French.*

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3

1967. Note on electromagnetic moment of inertia. W. R. DIXON. *Amer. J. Phys.*, **19**, 536–7 (*Dec.*, 1951).

It is shown that the angular momentum of the stationary electromagnetic field surrounding a classical charged particle may be considered to be localized in the charge distribution. When the magnetic field is considered to be due to rotation of the charge, there exists a moment of inertia tensor relating the angular momentum of the field and the energy of the magnetic field to the angular velocity, just as the angular momentum, kinetic energy of rotation and angular velocity are related in ordinary mechanics. A.

538.3 : 550.838

A conducting sphere in a time varying magnetic field. *See Abstr.* 2275

538.3 : 621.3.011

1968. A critical study of the circuit concept. J. G. CHANEY. *J. Appl. Phys.*, **22**, 1429–36 (*Dec.*, 1951).

From Maxwell's equations, an expression for the complex power associated with a wire circuit is formulated and broken into a complex input power and a complex power into the external fields associated with the circuit, the latter including the radiated power. From these powers, the internal and external impedances of the circuit are obtained such that the current is not required to be everywhere in time phase within the circuit. This concept is extended to coupled circuits, bringing out some of the relations between some conventional methods for obtaining the driving point impedance of aerial arrays. The theory does not require the current distributions to be postulated, but in practical applications such a postulate becomes necessary unless the solution is obtained by a method such as the integral equation method. The resulting circuit design may readily be reduced to that for lumped elements. A more critical study of the impedance formulae is given, based upon the reciprocity theorem which is derived. A.

538.32 : 530.12 : 621.3.011

1969. Interaction between currents as a relativistic second order effect of electrostatic forces. H. PELZER AND S. WHITEHEAD; E. G. CULLWICK. Letter in *Brit. J. Appl. Phys.*, **2**, 330–2 (*Nov.*, 1951).

A rigorous deduction is made of the force acting between electric currents, using only Coulomb's law of electrostatic forces and the restricted theory of relativity without using magnetic concepts; this is equivalent to deducing the relation $\mu_0 k_0 c^2 = 0$, and was performed approximately by Cullwick [*The fundamentals of electromagnetism.* Cambridge (1949)]. Cullwick contributes a further example.

538.52

1970. The Tesla coil. J. B. KELLEY AND L. DUNBAR, SR. *Amer. J. Phys.*, **20**, 32 (*Jan.*, 1952).

A description of the construction and operation of a replica of a coil, such as Nikola Tesla first described in 1891, is presented. A.

538.521

1971. On the proximity effect and the mutual induction coefficient at high frequencies between a region of a conducting plane of great thickness and a conducting wire parallel to it. A. COLOMBANI. *C.R. Acad. Sci.* [*Paris*] **233**, 1267–9 (*Nov.* 19, 1951) *In French.*

538.54 : 621.838.3 : 621.318.3

1972. On an ultra-high-rotational instrument. G. SHINODA AND M. ITOH. *Techn. Rep. Osaka Univ.*, **1**, 151–6 (*Oct.*, 1951).

The mechanism of a magnetic bearing for ultra-high rotational speed has been studied analytically. Using an electromagnetic driving system for input power of the instrument, the characteristics were studied and the existence of both hysteresis loss in ferromagnetic materials and slip of a rotor were ascertained. A.

538.551 : 531.3 : 621.3.011

1973. Some general theorems for non-linear systems possessing resistance. W. MILLAR. *Phil. Mag.*, **42**, 1150–60 (*Oct.*, 1951).

Introduces some ideas and general theorems pertaining to non-linear or mechanical systems. Thus in the case of a resistive network, the dissipation is divided into two parts—the "content" and "co-content"—which are duals of each other. The dissipation itself has stationary properties in linear but not (in general) in non-linear networks, but it can be shown that the "content" and "co-content" have stationary and additive properties in the non-linear case. The idea of "content" is extended to reactive systems, and it is shown that the total content of any system in motion is an invariant. See also abstract following. A.

538.551 : 531.3 : 621.3.011

1974. Some general theorems for non-linear systems possessing reactance. C. CHERRY. *Phil. Mag.*, **42**, 1161–77 (*Oct.*, 1951).

The theorems and concepts presented here are generally applicable to circuits of electrical or mechanical elements with non-linear characteristics. The quantity called the co-energy (the dual of energy) is shown to possess stationary properties (maximum or minimum) and superposition properties; this is sufficient to establish the concept of an "equivalent element" for any 2-terminal system of like elements (all-inductor, all-capacitor, all-springs, etc.). The unfamiliar "rectangle representation" of a circuit of linear resistors is explained and extended to the non-linear case, including reactive elements. It is shown that the equations of motion of a non-linear system, possessing reactance, may be expressed in Lagrangian form, thus emphasizing the importance of co-energy and also showing that the Principle of Duality is applicable. Finally, systems are considered possessing mutual inductance and moving magnetic circuits (as in rotating machines). See also preceding abstract. A.

538.551 : 621.3.011

1975. On some points of the mathematical theory of linear circuits. A. González Domínguez. *Rev. Un. Mat. Argentina*, **14**, 275–322 (1950) *In Spanish.*

A study is made of what assumptions are required for the deeper parts of the theory of linear circuits. The fundamental function characterizing a circuit is taken to be the response $G(t)$ to the excitation which is 0 or 1 according as $t < 0$ or $t > 0$. A stable circuit is defined to be one such that the responses to bounded excitations are bounded, and such a circuit is characterized by the fact that $G(t)$ is of bounded total variation over the interval $(0, \infty)$. Various familiar properties of stable circuits are obtained. Some problems relating to the synthesis of circuits having prescribed properties are discussed.

MATHEMATICAL REVIEWS

538.551 : 621.3.014

1976. The output current of a nonlinear device. B. Salzberg. *Amer. J. Phys.*, 19, 555–61 (*Dec.*, 1951).

A voltage consisting of a cosine term superposed on a steady term is applied to the input of a non-linear device. The output current of the device is zero for negative voltages, and proportional to the nth power of the voltage when it is positive, the exponent n being 1, $\frac{3}{2}$ or 2. The resultant current may be zero, continuous, or discontinuous, depending on the relative values of the steady term and the peak value of the cosine term. In general, the current may be represented by a Fourier series, the coefficients of the various terms of which are functions of n and the magnitudes of the two components of the voltage. For $n = 1$ and $n = 2$, these coefficients are expressible in terms of trigonometric functions. For $n = \frac{3}{2}$, the coefficients are given in terms of the complete elliptic integrals K and E. The root-mean-square value of the current, for $n = 1$, $\frac{3}{2}$ and 2, is given in terms of trigonometric functions. Graphs of coefficients of the leading Fourier terms, and of the root-mean-square current, are presented for both continuous and discontinuous current, for $n = 1$, $\frac{3}{2}$ and 2. A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.565 : 621.396.611.4

1977. On the influence of circular holes in cavity resonators. W. Klein. *Z. angew. Phys.*, **3**, 253–9 (*No.* 7, 1951) *In German.*

When two or more cavity resonators are coupled directly through holes in mutually separating walls coupled circuits exist. The theory and influence of coupling on the behaviour of cavity resonators are described. The experimental investigations were carried out on $\lambda = 10$ cm and 25 cm. Z. F. WOJNAR

538.566

1978. A method analogous to the WKB-method for the development of field patterns. W. Braunbek. *Z. Naturforsch.*, **6a**, 672–6 (*Nov.*, 1951) *In German.*

Discussion on the representation of the field of complex amplitude $m \exp ikz$. The possibility of a complex z leads to the usual WKB (Wentzel–Kramers–Brillouin) method, whereas the possibility of a complex m is here discussed in detail. A homogeneous cylindrical wave is used to illustrate the new method yielding agreement with the WKB system.

Z. F. WOJNAR

538.566

1979. Diffraction by a wave-guide of finite length. D. S. Jones. *Proc. Camb. Phil. Soc.*, **48**, 118–34 (*Pt I*, 1952).

When the electric intensities on two parallel planes, of which the two perfectly conducting sides of a waveguide of finite length and infinite width are portions, are taken as unknowns, the problem of the diffraction of a plane harmonic electromagnetic wave polarized parallel to the edges of the guide leads to two integral equations. By means of the Laplace transform these equations are converted into others suitable for solution by successive substitutions. The series thus obtained is too complex for practical purposes, and so an approximate solution is found for the case when the length of the guide is large compared with the wavelength. Finally, there is a brief discussion of the difference between the distant fields when l is large and when l is infinite. I A.

538.566

1980. On the approximate solutions of Maxwell's equations in an infinite medium with regions of finite conductivity. K. V. K. Prasad. *Indian J. Phys.*, **25**, 403–7 (*Aug.*, 1951).

The approximate solutions of Maxwell's equations lead to solutions of the normal mode type for the propagation of electromagnetic waves inside waveguides. The failure of such normal mode type solutions to describe the entire field of a given source has been discussed in the case of propagation along a tube of circular cross-section. A.

538.566 : 621.392.26

1981. A reflectionless wave-guide termination. R. E. Grantham. *Rev. Sci. Instrum.*, **22**, 828–34 (*Nov.*, 1951).

A design which, in principle, can be adapted to waveguide or coaxial transmission lines. Reflection coefficients of 0·001 were obtained experimentally with X-band waveguide terminations. The termination comprises a section of transmission line into which is fitted a tunable sliding load. The sliding load is tuned to be reflectionless by means of the "sliding load" method of measuring reflection coefficients. The termination can be operated over a wide frequency range but must be retuned each time the frequency is changed. The waveguide circuit of the load is analysed and design equations are derived. The reflectionless waveguide termination is primarily useful as a reference standard for microwave impedance bridges. A.

538.566 : 621.396.671

1982. General theory of electromagnetic horns. A. F. Stevenson. *J. Appl. Phys.*, **22**, 1447–60 (*Dec.*, 1951).

Exact equations for the propagation of electromagnetic waves in a perfectly conducting horn of arbitrary shape are given. They take the form of an infinite set of simultaneous ordinary linear differential

equations, and can be interpreted as the equations of propagation of a system of coupled *E*- and *H*-waves. If the coupling is neglected only a single differential equation need be considered for each *E*- and *H*-wave, which can be solved approximately by the WKB method. This approximate solution brings out the distinction between "transmission regions" and "attenuation regions" of the horn, as found by Barrow and Chu for the sectoral horn. It is shown that the error due to neglect of coupling is, in general, of the order of the square of the flare angle as far as the variation of the field along the horn is concerned, but is of the first order in the flare angle as regards the variation of the field over the cross-section. The coupling cannot, however, be neglected between modes of propagation which have the same cut-off frequency for all cross-sections. The propagation characteristics of several special shapes of horn are discussed in detail. A.

538.566 : 621.396.671.4

1983. Radiation resistance of a dipole near a conducting ellipsoid of revolution. R. G. Mirimanov. *Dokl. Akad. Nauk SSSR*, **80**, 189–92 (*No.* 2, 1951) *In Russian.*

538.566.2 : 523.53

Theory of radio reflections from meteor trials. I. *See Abstr.* 1400

538.566.2 : 621.396.11

1984. Propagation of electromagnetic waves over an inhomogeneous soil. M. Argirović. *Elektroteh. Vestn.*, **19**, 225–31 (*No.* 8–9, 1951) *In Croatian.*

A new analytical method of calculating the propagation of ground waves over an inhomogeneous soil. Based on the formula for the numerical distance in the field equation it is proved that the total numerical distance ρ equals the sum of the particular distances. This is true up to the point where the total numerical distance exceeds its critical value which is $\rho_{cr} = \pm 2{\cdot}74$. In this case negative roots for the numerical distance resulting from the quadratic equation defining ρ must be taken into account. By means of two examples of the calculation of theoretical curves for field attenuation, the causes of the irregular shape of these curves (i.e. the field intensification with distance) for propagation over sea and shore are shown, which irregularity could not be fully explained hitherto. The formula for the equivalent conductivity enables a simple method of measuring the single values of the conductivity of inhomogeneous soils to be used in the case $\rho < \rho_{cr}$. A.

538.566.2 : 621.396.11(684)

1985. Atmospheric super-refraction and the anomalous propagation of radio waves off the coast of Natal. W. E. Phillips. *S. Afr. J. Sci.*, **48**, 163–5 (*Dec.*, 1951).

Experimental evidence indicates that very short radio waves are propagated close to the surface of the earth over distances greatly in excess of the optical distances under favourable meteorological conditions. There is further evidence that energy thus propagated is in the nature of a ground wave confined to a "radio duct," and that the Kennelly–Heaviside layer plays no part in such propagation. The dependence of duct formation on the phenomenon of atmospheric super-refraction is well known, and observations taken off the coast of Natal are given. A.

538.566.3

1986. Comparison of results of ionospheric absorption measurements made at two European stations. K. Rawer. *J. Atmos. Terr. Phys.*, **2**, 38–50 (*No.* 1, 1951) *In French.*

A general discussion of the usual method of absorption measurements reveals some difficulties of physical interpretation. With the Slough absorption measurements the following three results have been obtained: (*a*) The seasonal variation follows a $\cos \chi^{\frac{3}{2}}$ law, but only in summer. (*b*) The influence of the solar cycle is important. (*c*) A considerable fluctuation exists from one day to another. Such daily values measured at Slough and Freiburg (distance 400 km) have been compared. They mostly show a positive correlation, but the correlation coefficient is only of the order of 0·4. Some of the difference seems to be brought about by local phenomena, but this conclusion is not yet certain, because the method of measurement is somewhat different. A new measure of correlation, which is rapidly calculated, is proposed. A.

538.566.3

1987. The contributions of the *D* and *E* regions in measurements of ionospheric absorption. K. Bibl and K. Rawer. *J. Atmos. Terr. Phys.*, **2**, 51–65 (*No.* 1, 1951) *In French.*

Observations of ionospheric absorption made on different frequencies reveal an important contribution of selective absorption occurring in the *E*-layer. This influence can be calculated with the model of a parabolic *E*-layer and an exponential variation of the collision number. With the results of this calculation a new evaluation of the measurements of Slough and Freiburg has been made for 24 months. A graphical method is proposed, which gives separately the contributions of the *E*- and *D*-layers. These values for *D*-absorption are, of course, not as high as can be obtained by the usual method, where the influence of the *E*-layer is neglected. In spite of a considerable dispersion this evaluation leads to the adoption of a rather constant value of the influence of the *E*-layer. It is proposed to use this value for future reduction of absorption measurements. Finally this constant leads to a new determination of the number of collisions in the centre of the *E*-layer, which is certainly below $10^4[s^1](6{\cdot}5 \times 10^3[s^1])$. This value, lower than those of other observers, is in good accordance with recent temperature and pressure data at 125 km. A.

538.566.3

1988. A method for obtaining the wave solutions of ionospherically reflected long waves, including all variables and their height variation. J. J. Gibbons and R. J. Nertney. *J. Geophys. Res.*, **56**, 355–71 (*Sept.*, 1951).

A method is presented for obtaining solutions to the one-dimensional wave equation $\pi''/\pi = -K_0^2\varepsilon^2(x)$ which arises in the course of the application of the wave theory to the study of the ionosphere. The π's represent characteristic wave functions of the ionosphere, K_0 the propagation constant of free space, $\varepsilon(x)$ the complex index of refraction of the ionosphere,

and the primes denote differentiations with respect to the space co-ordinate x. The method has been applied on "E-layer" problems with good results. An example of the method for obtaining the wave functions and reflection coefficients is carried out in detail, and reflection coefficients are presented for five different values of maximum electron density. This method is compared with the ray optics and the WKB method. The results are compared very briefly with experiment.

538.566.3 : 621.396.11

1989. On the generation of higher harmonics in the ionosphere. K. FÖRSTERLING AND H-O. WÜSTER. *J. Atmos. Terr. Phys.*, **2**, 22–31 (*No.* 1, 1951) *In German.*

This paper continues previous studies on the propagation of plane electromagnetic waves in an inhomogeneous medium with plane stratification. Near a zero of the dielectric constant, the electric field-component parallel to the plane of incidence shows a singularity, and it becomes infinite if the damping vanishes. While, for the vicinity of a simple zero, that fact can be proved only by developments into power-series, the case of a double zero allows one to derive the singularities by a solution of Maxwell's equations in terms of known functions. The singularity, thus stated, causes the generation of higher harmonics not radiated by the transmitter. A.

538.566.3 : 621.396.11

1990. The polarization of vertically incident long radio waves. J. M. KELSO, H. J. NEARHOOF, R. J. NERTNEY AND A. H. WAYNICK. *Ann. Geophys.*, **7**, 215–44 (*No.* 4, 1951).

The polarization of long electromagnetic waves in the ionosphere is considered. The analytical expressions relating $N - \nu$ distributions of the ionosphere to the characteristic polarizations are developed. The polarization of the electromagnetic waves leaving the ionosphere is treated in two ways. The wave is treated as a single magneto-ionic component. It is shown that under certain conditions the wave does behave as a single component which attains a "limiting polarization" at some N value $N \neq 0$. It is shown, however, that this analysis breaks down under certain conditions and in fact wave polarizations occur which are not characteristic polarizations associated with any $N - \nu$ value. It is shown that a model consisting of electron D and E-regions is capable of giving polarization results which are in good agreement with experiment. A.

538.566.3 : 621.396.11

1991. Lateral ray-displacement on reflection at a non-homogeneous ionospheric layer. K. RAWER. *Z. angew. Phys.*, **3**, 226–7 (*No.* 6, 1951) *In German.*

The theory of radio-wave propagation in a non-homogeneous ionospheric layer is considered and in particular the sideways displacement of the ray-path. It is suggested that certain cases of propagation on frequencies in excess of the calculated M.U.F. may be explained in this way. W. J. G. BEYNON

538.566.3 : 621.396.11 : 621.396.812.3

1992. Effects of ionosphere disturbances on low frequency propagation. J. M. WATTS AND J. N. BROWN. *J. Geophys. Res.*, **56**, 403–8 (*Sept.*, 1951).

Results of vertical-incidence pulse observations show that ionospheric storms have appreciable effects on the reflective properties of the E-region at night. Daytime effects of storms are limited primarily to periods of high absorption, coinciding with similar effects at higher frequencies. Data obtained at 160 kc/s indicate that the character of low frequency reflections at night may be a sensitive indication of storminess. Correlation is shown between magnetic K-indices and low-frequency data. During storms, effects have been of such magnitude that they cannot be ignored in design of low-frequency navigational or high-speed communications systems. A.

MAGNETIC EFFECTS 538.6

538.614 : 548.0

1993. Faraday effect and birefringence. II. Corundum. S. RAMASESHAN. *Proc. Indian Acad. Sci. A*, **34**, 97–100 (*Aug.*, 1951).

For Pt I, see *ibid.*, **34**, 32 (1951). The Verdet constant and the magneto-optic anomaly for corundum for light travelling along the optic axis have been determined for the wavelengths λ 5 893, λ 5 461 and λ 4 358. The Verdet constant has the values $V_{5893} = 0{\cdot}0210'$, $V_{5461} = 0{\cdot}0240'$ and $V_{4358} = 0{\cdot}0381'$ minutes per cm. per Oersted and γ has a value of 0·64. Accurate measurements have also been made for directions of propagation inclined to the optic axis and it is found that the Verdet constant does not sensibly change for an inclination of about 15° away from the optic axis. A.

538.639

1994. The anomalous magnetoresistance of bismuth at low temperatures. P. B. ALERS AND R. T. WEBBER. Letter in *Phys. Rev.*, **84**, 863–4 (*Nov.* 16, 1951).

Previous measurements by de Haas *et al.* [*Physica*, **2**, 907 (1935)] were extended to fields $> 6 \times 10^4$ oersted. The magnetoresistance is a complex function of field and of the angles between the trigonal and geometrical axes and between the binary axis and the field. It is believed that impurity and size effects are important in interpreting the results.

E. P. WOHLFARTH

538.65 : 536.25

1995. Thermal convection in a magnetic field. W. B. THOMPSON. *Phil. Mag.*, **42**, 1417–32 (*Dec.*, 1951).

The modifications produced in the Rayleigh–Jeffreys theory of slow thermal convection by magneto-hydrodynamic effects in a conducting fluid placed in a magnetic field are examined. Even for a non-viscous fluid, a critical temperature gradient β_0 must be exceeded in order that convection occur. In this, the place of viscosity η occurring in the Rayleigh–Jeffreys formula is taken by a quantity η_H depending on the conductivity of the fluid, the magnetic field strength H and depth of fluid d, thus $\eta_H = (4/27)(d^2/\pi^2)(\sigma\mu^2 H^2/c^2)$. If the fluid is viscous a multiple of the normal viscosity depending on H must be added to η_H. An estimate of the critical gradient is made for somewhat artificial boundary

conditions and it is found large enough to be experimentally detectable. The applicability of Jeffreys' method of marginal stability is discussed and the nature of possible oscillations investigated. A.

538.652

1996. Magnetostrictive vibration of prolate spheroids. Analysis and experimental results. F. J. Beck, J. S. Kouvelites and L. W. McKeehan. *Phys. Rev.*, **84**, 957–63 (*Dec.* 1, 1951).

Small centrally-clamped ferromagnetic specimens are uniformly and axially magnetized by an applied static field. They are simultaneously subjected to an axial h.f. magnetic field and allowed to vibrate longitudinally in the frequency region of their fundamental mode. Through an analysis of this vibrational system, a method is developed whereby from the resonance changes of the impedance of the h.f. magnetizing coil, values may be computed for the incremental permeability, magnetostriction constant, modulus of elasticity, and dissipation constant of the ferromagnetics. Annealed specimens of Ni and of several Ni–Fe alloys, as well as the Ni in the unannealed state, were thus tested. The variations of the physical parameters with composition, magnetic bias, and heat treatment, are examined qualitatively in the light of present domain theory and found to be consistent. A good quantitative check of the experimental method is provided by the calculation of the saturation magnetostriction of nickel as $-36{\cdot}7\times10^{-6}$. A.

538.66

1997. A note on the adiabatic thermomagnetic effects. H. B. Callen. *Phys. Rev.*, **85**, 16–20 (*Jan.* 1, 1952).

The thermodynamic theory of the transverse adiabatic thermomagnetic effects is extended; and the final complete set of thermodynamic relations among all thermomagnetic effects is summarized. A.

538.69 : 536.212.2

The thermal conductivity of cadmium in a magnetic field at low temperatures. *See Abstr.* 1703

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

1998. On the quantum theory of the many-electron problem in solids. H. Volz and H. Haken. *Z. phys. Chem.*, **198**, 61–74 (*No.* 1–4, 1951) *In German.*

An n-electron system having potential energy $\sum_{i<k} G(x_i - x_k) + \sum_i V(x_i)$ is considered, where G gives the electron interaction energy and V the potential energy of an electron in the field of the positive ions. V is treated as a periodic function, and this is justified by assuming a screened Coulomb interaction in both V and G. The wave-function is found to have the form $\psi = \mu_K(X; \ldots \xi_{ik} \ldots)\exp(iKX)$ in generalization of the Bloch wavefunction (X = co-ordinate of mass centre of electrons, ξ_{ik} = distance between ith and kth electron). In the presence of an electric field E the wave vector K satisfies $hK = neE$.

P. T. Landsberg

539.11

1999. Note on the interaction of an electron and a lattice oscillator. E. P. Gross. *Phys. Rev.*, **84**, 818–23 (*Nov.* 15, 1951).

The interaction of an electron and a lattice oscillator is studied for an interaction energy of a special type linear in the oscillator co-ordinates and momenta. The energy values and eigenfunctions for arbitrary coupling strength are found by solving a three-term recurrence relation. A plot of energy v. total momentum of electron plus oscillator reveals the role of degeneracies of states involving different numbers of quanta in the oscillator. As the frequency of the oscillator tends to zero, one finds the bandlike spectrum characteristic of an electron moving in a periodic potential. With increasing total momentum the electron makes Bragg reflections, transferring quanta of energy and momentum to the oscillator, and remaining bounded in velocity. For strong coupling the state of minimum energy is one of nonzero total momentum. For sufficiently strong coupling, regions of small effective electron mass cease to exist. A.

539.11 : 535.371

Radiationless electron transitions in crystals. *See Abstr.* 1656

539.11 : 539.132

Calculation of the cohesive energy of molecules and crystals; sodium. *See Abstr.* 2020–21

MOLECULAR STRUCTURE 539.13

539.13

2000. A quantum mechanical study of lithium hydride. I. Fischer. Letter in *Nature* [*Lond.*] **168**, 1002 (*Dec.* 8, 1951).

The binding energy was computed with wave functions taking account of all 4 electrons; for $R = 1{\cdot}6$ Å this was 2·0 eV. The structure Li^+H^- seems the most important one. J. Jacobs

539.132

2001. Hydrocarbon structure and bond properties. Introductory paper. M. G. Evans. *Disc. Faraday Soc.*, *No.* 10, 1–9 (1951).

539.132

2002. A survey of the principles determining the structure and properties of molecules. I. The factors responsible for molecular shape and bond energies. J. Lennard-Jones and J. A. Pople. *Disc. Faraday Soc.*, *No.* 10, 9–18 (1951).

In this paper a general account of the basic factors determining the structure of molecules is presented. It is pointed out that previous theories used to explain the structure of molecules are inconsistent in certain respects and tend to obscure the nature of the forces operating. Here it is shown that a satisfactory qualitative picture of the structure of a molecule can be obtained by considering only electrostatic repulsions operating in conjunction with the antisymmetry

principle. This is applied to the relative position of bonds and lone pairs in molecules and then to the interaction of two electrons in a bond. In the concluding sections, it is shown how the same qualitative ideas can be applied to strained hydrocarbons and to simple free radicals. A.

539.132

2003. A survey of the principles determining the structure and properties of molecules. II. The ionization potentials and resonance energies of hydrocarbons. J. Lennard-Jones and G. G. Hall. *Disc. Faraday Soc., No.* 10, 18–26 (1951).

The theory of molecular orbitals provides a suitable method of calculating the ionization potentials of molecules. In this paper the method is applied to saturated hydrocarbons and it is found to account satisfactorily for the change in the ionization potentials of paraffin molecules as the length of the chain is increased. The theory is applied also to unsaturated hydrocarbon molecules and an examination is made of methods previously used to calculate resonance energies. It is shown that the results of earlier work can be given a different interpretation from that usually accepted. In this new theory ionization potentials play an important part. A.

539.132

2004. Estimates of average bond energies and resonance energies of hydrocarbons. G. Glockler. *Disc. Faraday Soc., No.* 10, 26–35 (1951).

Average bond energies of hydrocarbons are estimated on the basis that the heat of sublimation of carbon $L(C) = 169{\cdot}7$ kcal. It is assumed that the experimental values of the CC— and the CH— distances of the three molecules ethane, ethylene and acetylene yield a relation between these distances which also holds for all other hydrocarbon molecules. It means that carbon-carbon bonds of relatively high average bond energy associate with carbon-hydrogen bonds of relatively high average bond energy. These average bond energies are used to calculate resonance energies. It is emphasized that these latter quantities depend on the reference state chosen. The method of calculating resonance energies from heats of hydrogenation is analysed and it is found that this procedure must be amplified by also considering the resonance energies and other effects which tend to change the average bond energies of the intermediate structures. The hydrogenation of butadiene to butene and butane and of benzene to 1 : 3-cyclohexadiene, cyclohexene and cyclohexane are discussed as examples. A.

539.132

2005. Potential energies for rotation about single bonds. K. S. Pitzer. *Disc. Faraday Soc., No.* 10, 66–73 (1951).

The theoretical relationships between the potential energy function for internal rotation and the energy levels and thermodynamic properties are summarized briefly. The height and shape of the potential barrier in ethane are re-examined in relation to all pertinent data. It is concluded that the barrier is very close to the cosine function in shape and from 2 750 to 3 000 cal./mole in height. The barrier heights for a number of other hydrocarbons are summarized and a few comments are made concerning the cause of these barriers. A.

539.132

2006. The present status of the problem of hindered rotation in hydrocarbons and related compounds. J. G. Aston. *Disc. Faraday Soc., No.* 10, 73–9 (1951).

539.132

2007. Restricted rotation in ethane. L. J. Oosterhoff. *Disc. Faraday Soc., No.* 10, 79–87 (1951).

The electrostatic interaction between the methyl groups in ethane is investigated. The charge distributions of the C—H bonds are calculated with wave functions of the same type as those used by Coulson when discussing the dipole moment of this bond [Abstr. 212 (1943)]. By expanding the reciprocal distance, which occurs in the Coulomb interactions, in a Fourier series it proves possible to calculate directly the $\cos 3\phi$ term in the interaction energy. The $\cos 6\phi$ term proves to be negligible in comparison. With a purely covalent bond the electrostatic energy of the methyl groups depends only to a negligible extent on the angle of rotation ϕ. The right order of magnitude of the potential barrier is obtained if an ionic contribution of the type C^-H^+ is added, leading to a bond dipole moment of 0·7 D with the sense C^-H^+. Since the relation between the calculated dipole moment and the empirical values as derived, for example, by means of spectroscopy, is still vague, it is premature to conclude that the electrostatic interactions of bonds with fixed charge distributions are the origin of the potential barrier in ethane. A.

539.132

2008. A study of two-center integrals useful in calculations on molecular structure. I. C. C. J. Roothaan. *J. Chem. Phys.*, **19**, 1445–58 (*Dec.*, 1951).

Convenient formulae have been obtained for the overlap integrals $\int \chi_a \chi_b dv$, kinetic energy integrals $-\frac{1}{2}\int \chi_a \Delta \chi_b dv$, nuclear attraction integrals $Z\int \chi_a(1/r_a)\chi_b dv$ and $Z\int \chi_b(1/r_a)\chi'_b dv$, and Coulomb repulsion integrals $\int\int \chi_a(1)\chi_b(2)(1/r_{12})\chi'_a(1)\chi'_b(2)dv_1 dv_2$, where χ_a, χ'_a, χ_b χ'_b are Slater-type AO's on the centres a and b. Explicit formulae are given for all the integrals arising from the principal quantum numbers 1 and 2, for arbitrary values of the effective nuclear charges and the interatomic distance. A.

539.132

2009. A study of two-center integrals useful in calculations on molecular structure. II. The two-center exchange integrals. K. Rüdenberg. *J. Chem. Phys.*, **19**, 1459–77 (*Dec.*, 1951).

The problem of the two-centre exchange integrals is solved in the most general way for Slater-type atomic orbitals with integral effective quantum numbers. No other restrictions are placed upon effective quantum numbers and effective nuclear charges. The integrals are expressed linearly in terms of certain auxiliary functions. A rule for finding the coefficients is given. The coefficients are explicitly computed for all cases involving orbitals with the quantum numbers 1, 2 and 3. The auxiliary functions are discussed in detail. The existing literature is reviewed and a survey of present tables is made. A.

539.132

2010. Semilocalized orbitals. I. The hydrogen molecule. C. R. Mueller and H. Eyring. *J. Chem. Phys.*, **19**, 1495–8 (*Dec.*, 1951).

Semilocalized orbitals are defined and applied to the H molecule. The basic criteria for the analytic form of this kind of orbital is that it shall assume either molecular or atomic orbital form for certain special values of the variational parameters. A binding energy of 4·20 eV is found in comparison with 3·60 and 3·76 eV obtained from the best molecular and atomic orbital calculations. The physical interpretation of the results is briefly discussed. A.

539.132

2011. Semilocalized orbitals. II. A comparison of atomic, molecular, and semilocalized orbital method for diatomic hydrogen fluoride. C. R. Mueller. *J. Chem. Phys.*, **19**, 1498–9 (*Dec.*, 1951).

The method of Pt I is applied to diatomic HF simultaneously with atomic and molecular orbital calculation. In contrast to the results with the H molecule, the semilocalized orbitals are closer to molecular than atomic orbital form. The semilocalized orbitals give a much better binding energy than molecular orbitals and the improvement in dipole moment calculations is especially heartening. The results with the atomic orbital method are very discouraging. A.

539.132

2012. Substituted methanes. VII. Vibrational spectra, force constants, and calculated thermodynamic properties for CH_3I and CD_3I. P. F. Fenlon, F. F. Cleveland and A. G. Meister. *J. Chem. Phys.*, **19**, 1561–6 (*Dec.*, 1951).

For Pt VI see Abstr. 6375 (1951). Raman displacements for the liquid, and infrared absorption wave numbers for both liquid and gas, have been obtained for CH_3I, together with quantitative depolarization factors for the Raman lines and semiquantitative relative intensities for both the Raman and infrared bands. The present and previous data were critically compared, and probable values of the wave numbers corresponding to the fundamental vibrational frequencies were determined for both liquid and gaseous states. Force constants in a modified valence force potential function, containing all possible quadratic interaction constants, were calculated; these then were used to calculate the fundamentals of CD_3I. Finally, the heat content, free energy, entropy and heat capacity for both CH_3I and CD_3I were calculated for 11 temperatures from 200° to 1 000°K, for the ideal gaseous state at 1 atmos. pressure. A.

539.132

2013. On the theoretical calculation of transition probabilities. H. Shull and F. O. Ellison. Letter in *J. Chem. Phys.*, **19**, 1610–11 (*Dec.*, 1951).

The transition integral is shown to be independent of the choice of origin, contrary to the statement of Bayliss [Abstr. 1223 (1951)], provided the wave functions are orthogonal. A. J. TAYLOR

539.132

2014. Irreducible representations of cubic groups. F. Matossi. Letter in *J. Chem. Phys.*, **19**, 1612–13 (*Dec.*, 1951).

A set of matrices is given for the *E* species and the *F* species of the group *Td*. A. J. TAYLOR

539.132

2015. Theoretical determination of electron density in organic molecules. C. A. Coulson, P. W. Higgs and N. H. March. Letter in *Nature* [*Lond.*] **168**, 1039 (*Dec.* 15, 1951).

See also Abstr. 8876 (1951). Calculations show that (i) parallel to the molecular plane the σ-electron density exceeds that of π-electrons, (ii) the max. electron density in a vibrating molecule (v.m.) is well below that of a non-vibrating molecule (n.-v.m.), affecting comparisons of X-ray measurements (v.m.) with theoretical values (n.-v.m.). J. JACOBS

539.132

2016. Theory of molecular hydrogen and deuterium in magnetic fields. N. F. Ramsey. *Phys. Rev.*, **85**, 60–4 (*Jan.* 1, 1952).

The Hamiltonian of a diatomic homonuclear molecule in a magnetic field is discussed. Included in the Hamiltonian are the effects of the nuclear and rotational magnetic moments interacting with the external magnetic field, magnetic shielding, molecular diamagnetism, the spin-spin magnetic interaction of the two nuclei, the interaction of the nuclear magnetic moments with the field due to the rotation of the molecule, and the interaction of nuclear electric quadrupole moments. Perturbation theory expressions for the energy of H_2 and D_2 in the first rotational state are obtained in both strong and weak field limits. The secular equation is numerically solved for intermediate fields. Curves are given showing the theoretical dependence of the energy and the transition frequencies upon the field. A.

539.132 : 535.338.4

2017. Computation of the intensities of vibrational spectra of electronic bands in diatomic molecules. C. Manneback. *Physica*, **17**, 1001–10 (*Nov.–Dec.*, 1951).

A simple recurrence procedure is developed for computing the matrix of the amplitudes of probabilities (transition-moment), leading to the intensities of the vibrational spectrum in electronic bands of diatomic molecules. The results are only given for the case of harmonic motion in both upper (excited) and lower (ground) states, but the method is not limited to this hypothesis. This paper does not enter into a full discussion of the physical results. For practical use, only numbered formulas are required. A.

539.132 : 535.343.4

2018. Pressure-induced absorption. I. The calculation of pressure-induced absorption in pure hydrogen and deuterium. J. van Kranendonk and R. B. Bird. *Physica*, **17**, 953–67 (*Nov.–Dec.*, 1951).

The pressure-induced infrared absorption in the usually forbidden 0–1 vibrational band of hydrogen and deuterium has been calculated by considering in detail the molecular distortions induced during binary collisions, which result in an absorption proportional

to the square of the density (at constant volume). The total induced dipole moment of an interacting pair of molecules consists of two contributions: (i) an "atomic distortion effect" resulting from the overlap forces, which is predominantly responsible for the Q-branch, and (ii) the "quadrupole distortion effect" resulting from the polarizing effect of the permanent quadrupole moments of the molecules, which effect is primarily responsible for the O- and S-branches. The calculated total absorption coefficients at 300°K for the 0–1 band of H_2 are about half as big as the experimental values [Abstr. 5345 (1949), 160 (1950), 2538 (1951)]; this agreement is satisfactory inasmuch as the calculated results depend strongly on several quantities which are not well known. The relative intensities of the O-, Q- and S-branches, however, are in close agreement with the experimental values. A.

539.132 : 535.343.4

2019. Pressure-induced absorption. II. The calculation of pressure-induced absorption in hydrogen–helium mixtures. J. VAN KRANENDONK AND R. B. BIRD. *Physica*, **17**, 968–76 (*Nov.–Dec.*, 1951).

The theory is extended to include an explanation of the phenomenon in mixtures. The enhancement of H_2 and D_2 infrared absorption due to the addition of helium is calculated for 300°K, and the results are compared with the available experimental measurements. The theory explains the fact that the ratio of intensities $S : Q$ is less for H_2–He than for pure H_2. A.

532.132 : 539.11

2020. On the quantum mechanical calculation of the cohesive energy of molecules and crystals. I. A general formula for the ground state. P. O. LÖWDIN. *J. Chem. Phys.*, **19**, 1570–9 (*Dec.*, 1951).

A simple expression for the energy of the ground state of a molecule or a crystal is derived by starting from a total wave function, which is a Slater determinant of molecular spin orbitals or Bloch spin orbitals, formed by linear combinations of atomic orbitals. By the introduction of the new idea of "combined atomic orbitals," the energy is expressed only in terms of two-centre integrals of atomic orbitals, but the formula still includes the bonding and the overlapping between neighbours of all orders, and further, all the three-centre and four-centre integrals occurring in previous formulae. A simplified expression of the cohesive energy is given for the case where the given atomic orbitals belong to the self-consistent field with exchange of the free atoms. A.

539.132 : 539.11

2021. On the quantum mechanical calculation of the cohesive energy of molecules and crystals. II. Treatment of the alkali metals with numerical applications to sodium. P.-O. LÖWDIN. *J. Chem. Phys.*, **19**, 1579–91 (*Dec.*, 1951).

The method of Pt I is here applied to the calculation of the cohesive energy of the alkali metals, where, due to the crystal symmetry, the combined atomic orbitals for the valence electrons are almost pure s-functions. It is shown that the conventional method, taking only the interaction between nearest neighbours into account, is entirely insufficient, and that it is necessary to consider even bonding, overlapping and electronic repulsion effects between neighbours of a rather high order. Numerical applications, including interactions between neighbours up to the order nine, are carried out for metallic sodium, giving the cohesive energy 24·7 kcal/mol and the interatomic distance 3·69 Å, in good agreement with the experimental values 26 kcal/mol and 3·67 Å, respectively. Except for the values of the fundamental constants e, m, h, . . ., no empirical data are used. A.

539.132 : 541.56

2022. Relationship of electron distribution in amines to ammine stability. W. S. FYFE. Letter in *Nature* [*Lond.*] **169**, 69–70 (*Jan.* 12, 1952).

Formation constants of Ag complexes with some amines were measured; the order of stability agrees with that indicated by the order of π-electron densities on the N atom. J. JACOBS

539.133

2023. The pure quadrupole spectrum of solid vinyl chloride. J. H. GOLDSTEIN AND R. LIVINGSTON. Letter in *J. Chem. Phys.*, **19**, 1613 (*Dec.*, 1951).

539.133

2024. Charge densities in conjugated systems. R. MCWEENY. Letter in *J. Chem. Phys.*, **19**, 1614–15 (*Dec.*, 1951).

Charge clouds are localized at atoms and in bonds by use of suitable LCAO'S. Effective dipole moments for atoms in molecules and properties of the electron configuration can be deduced from these local charges. J. JACOBS

539.133

2025. Rotational magnetic moments of $^1\Sigma$ molecules. J. R. ESHBACH AND M. W. P. STRANDBERG. *Phys. Rev.*, **85**, 24–34 (*Jan.* 1, 1952).

The theory of the rotational magnetic moment in $^1\Sigma$ molecules is presented. This theory is applied in particular to describe experiments on the Zeeman effect for a linear rotor, OCS, and a symmetric top, NH_3. A.

539.133 : 535.325–15

2026. The infrared dispersion of acetylene and the dipole moment of the C–H bond. R. L. KELLY, R. ROLLEFSON AND B. S. SCHURIN. *J. Chem. Phys.*, **19**, 1595–9 (*Dec.*, 1951).

The index of refraction of acetylene has been measured at 55 wavelengths in the infrared between 1 and 20 microns. The contributions of the molecular vibrations to the index of refraction have been determined and interpreted in terms of effective charges on the constituent atoms. According to the analysis, during the infrared-active bending vibration the H atoms have an effective charge of $0{\cdot}991 \times 10^{-10}$ e.s.u. The product of this effective charge by the separation of the C and H atoms is interpreted as giving an estimate of the C–H bond moment, the value obtained being $(1{\cdot}05 \pm 0{\cdot}01) \times 10^{-18}$ e.s.u. cm. For the active stretching vibration, the computed effective charge was $0{\cdot}515 \times 10^{-10}$ e.s.u., which is the rate of change of bond moment with internuclear distance. A comparison of these results with previous work indicates a possible regularity in the C–H bond moment in going from methane to ethylene to acetylene, although the regularity may be only apparent. A.

ATOMIC STRUCTURE . NUCLEUS ISOTOPES 539.15

539.152.1

2027. Potential and field of a volume distribution of quadrupoles. M. LAUDET. *C.R. Acad. Sci.* [*Paris*] **233,** 1172–4 (*Nov.* 12, 1951) *In French.*

These are shown to be equivalent to those due to suitable volume and surface charges and a suitable dipole distribution. The potential and the tangential component of the field are not continuous across the surface. W. J. SWIATECKI

539.152.1

2028. The uniform theory of nuclear binding energies. D. H. FRISCH. *Phys. Rev.*, **84,** 1169–77 (*Dec.* 15, 1951).

Wigner's "uniform" theory of nuclear binding energies is reviewed with the following additions: (1) the potential energy is generalized by using other exchange operators as well as the Majorana operator; (2) a rough calculation of the magnitude of the interaction integrals is made from the central forces between the elementary nucleons, leading to a calculation of the potential energy and a discussion of stability at the observed nuclear radii. The results are that the uniform model cannot be improved appreciably by a reasonable more general central potential operator, and the calculated interaction integrals probably cannot give the observed binding energies and radii simultaneously. A.

539.152.2

2029. Quadrupole resonance frequencies of crystalline bromine. H. G. DEHMELT. *Z. Phys.*, **130,** 480–2 (*No.* 4, 1951) *In German.*

At 83°K polycrystalline Br_2 shows 2 absorption lines which are attributed to the Br^{79} and Br^{81} isotopes, each of nuclear spin 3/2. These measurements give nuclear quadrupole moments $Q_{79} = +0{\cdot}30\times10^{-24}$ cm², $Q_{81} = +0{\cdot}25\times10^{-24}$ cm². J. JACOBS

539.152.2

2030. The magnetic *g*-factors of a nucleon. C. CANDLER. *Proc. Phys. Soc.* [*Lond.*] *A*, **64,** 999–1002 (*Nov.*, 1951).

The nuclear magnetic moment is a two-valued function of the spin, and Schmidt's argument is used in reverse to induce the orbital and spin *g*-factors. g_l is shown to be unity in odd-proton and zero in odd-neutron nuclei, as theory has assumed, but g_s varies from nucleus to nucleus with a mean value about half that found in the free proton or neutron. The magnetic spin ratio *G*, defined as $g_s/g(\mathrm{p})$ in odd-proton and as $g_s/g(\mathrm{n})$ in odd-neutron nuclei, measures the approach of an empirical moment to a Schmidt line; it is shown to obey much the same rules in odd-proton and odd-neutron nuclei. A.

539.152.2

2031. Nuclear binding energies for isotopes with masses between 50 and 60. A. H. WAPSTRA. Letter in *Phys. Rev.*, **84,** 837–8 (*Nov.* 15, 1951).

Six isotopes are assigned mass values giving the best fit with reaction and mass-spectrographic data. W. J. SWIATECKI

539.152.2

2032. Nuclear masses and closed shells in the region $A < 65$. A. H. WAPSTRA. Letter in *Phys. Rev.*, **84,** 838–9 (*Nov.* 15, 1951).

A plot of the difference between assigned masses (see preceding abstract) and a semi-empirical formula suggests discontinuities at $N, Z = 8, 14, 28$. W. J. SWIATECKI

539.152.2

2033. The binding energy of four neutrons in U^{239} and the disintegration energies of U^{239} and Np^{239}. J. R. HUIZENGA, L. B. MAGNUSSON, M. S. FREEDMAN AND F. WAGNER, JR. Letter in *Phys. Rev.*, **84,** 1264–5 (*Dec.* 15, 1951).

The former is deduced as 22·21 MeV from neutron binding energies and α-energy systematics of U and Th isotopes. A re-examination of the β-spectra of U^{239} and Np^{239} gives 2·01 MeV for the sum of their disintegration energies. W. J. SWIATECKI

539.152.2

2034. On the magnetic moment of $Te^{123, 125}$ and Si^{29}. S. S. DHARMATTI AND H. E. WEAVER, JR. Letter in *Phys. Rev.*, **84,** 843–4 (*Nov.* 15, 1951).

From nuclear induction signals: $\mu(Te^{125}) = -0{\cdot}88235 \pm 0{\cdot}00004$; $\mu(Te^{123}) = -0{\cdot}73188 \pm 0{\cdot}00004$; $\mu(Si^{29}) = -0{\cdot}55492 \pm 0{\cdot}00004$ (assuming that its spin is 1/2). L. PINCHERLE

539.152.2

2035. The hyperfine structure of $^2P_{\frac{1}{2}}$ state of the stable chlorine isotopes. J. G. KING AND V. JACCARINO. Letter in *Phys. Rev.*, **84,** 852–4 (*Nov.* 15, 1951).

The atomic beam magnetic resonance method was used and, from observations of the h.f.s. interaction in an external field, the nuclear magnetic dipole coupling constants ($a_{\frac{1}{2}}$) for the above state were obtained. The result, $a(35/37) = 1{\cdot}201357 \pm 0{\cdot}000013$ is in excellent agreement with recent results on the ratio of the nuclear magnetic moments of the two isotopes. L. PINCHERLE

539.152.2

2036. Nuclear magnetic moment and *j–j* coupling shell model. M. MIZUSHIMA AND M. UMEZAWA. *Phys. Rev.*, **85,** 37–40 (*Jan.* 1, 1952).

It is shown that the magnetic moment of nuclei can be explained by a refined *j–j* coupling shell model, where neutron and proton shells are treated simultaneously, using the isotopic spin variable. The experimental moments agree well with the calculated ones for those states which have definite isotopic spin multiplicity. It is shown that a nuclear force caused by a neutral or symmetric meson is consistent with the results, but one caused by a charged meson is excluded. A.

539.152.2

2037. Polarization and alignment of nuclei. A. SIMON, M. E. ROSE AND J. M. JAUCH. *Phys. Rev.*, **84,** 1155–64 (*Dec.* 15, 1951).

Four methods for nuclear polarization and alignment are discussed and compared. In particular, a general theorem regarding the leading term in the expression for nuclear polarization by h.f.s. coupling with external field is obtained. A general method is

derived for treating the computation of higher order terms in the expansions of these quantities, as well as for use with complicated Hamiltonians, and application is made to 3 cases of interest. It is shown that the higher order terms are very small, in cases of interest, compared to the leading terms. A.

539.152.2 : 536.48

2038. Alignment of cobalt-60 nuclei at very low temperatures. C. J. Gorter, O. J. Poppema, M. J. Steenland and J. A. Beun. *Physica*, **17**, 1050–1 (*Nov.–Dec.*, 1951).

Anistropy of γ-ray emission was observed with a pure and a diluted cobalt ammonium Tutton salt similar to other recent observations [Abstr. 2630 (1950) 644 (1952)].

539.152.2.08

2039. A transitron nuclear magnetic resonance detector. H. W. Knoebel and E. L. Hahn. *Rev. Sci. Instrum.*, **22**, 904–11 (*Dec.*, 1951).

A simple circuit for obtaining nuclear magnetic resonance absorption signals has been developed. Conventional modulation of the magnetic field is replaced by frequency modulation of the oscillator, a method which is technically convenient for the accurate measurement of magnetic fields in the range of 1 000 to 18 000 gauss. The principles of operation and construction techniques are described in order that the user may readily duplicate results. A.

539.153

2040. On the configuration $fds + fs^2$ of Th II. D. Kessler. *Physica*, **17**, 913–19 (*Oct.*, 1951).

The experimental and calculated energy levels and g-values of the configuration fds and fs^2 of Th II are compared in intermediate coupling with interaction between the configurations. The energy levels are in very good agreement, the mean error being 1·4% of the configuration width. The agreement between the g-values is also satisfactory. A.

539.153

2041. Superposition of configurations in the ground state of He I. L. C. Green, M. M. Mulder, C. W. Ufford, E. Slaymaker, E. Krawitz and R. T. Mertz. *Phys. Rev.*, **85**, 65–7 (*Jan.* 1, 1952).

To obtain some understanding of the role played by various configurations in configuration interaction, the Hylleraas six-term expression for the ground-state wave function of He I has been expanded in series of orthogonal functions. To determine the degree of dependence of the coefficients of the expansion on the specific function used for the ground state, the Hylleraas three-term expression was also expanded. Two sets of orthogonal functions were used. One set consisted of orthogonalized symmetrized product type wave functions where the functions for the individual electrons were found from a Hartree self-consistent field without exchange. The second set consisted of orthogonalized variationally determined analytic wave functions. The results emphasize the large number of configurations which would have to be considered if the Hylleraas wave function were to be represented with high accuracy. After $1s^2$ the largest contributors among the configurations considered were $2p^2$ and $2s^2$. A.

539.153 : 530.145

2042. Relativistic corrections to the Lamb shift. M. Baranger. Letter in *Phys. Rev.*, **84**, 866–7 (*Nov.* 15, 1951).

The α^6 corrections were partly calculated using a decomposition of terms obtained with Feynman's methods. A correction of 6·89 Mc/s was obtained for the "second-order Lamb shift" improving agreement with experiment. L. Pincherle

539.155

2043. Atomic masses in the region about mass 40. T. L. Collins, A. O. Nier and W. H. Johnson, Jr. *Phys. Rev.*, **84**, 717–21 (*Nov.* 15, 1951).

The double-focusing mass spectrometer developed for the precise determination of atomic masses has been improved. A redetermination of the mass doublets $4C^{12} - S^{32}O^{16}$, $2O^{16} - S^{32}$ and $C^{12}H_4 - O^{16}$ lead to the following masses: $H^1 = 1{\cdot}008146 \pm 3$, $C^{12} = 12{\cdot}003842 \pm 4$ and $S^{32} = 31{\cdot}982236 \pm 7$. The relation of these results to those of other investigators is discussed. Mass doublet comparisons between hydrocarbon fragments and S^{32}, S^{33}, S^{34}, Cl^{35}, Cl^{37}, A^{36}, A^{38}, K^{39}, K^{41}, Ca^{42}, Ca^{43}, Ca^{44}, Ca^{48} and Sc^{55} have been made and mass values for these nuclides tabulated assuming both mass-spectroscopic and nuclear-reaction-determined mass values for H^1 and C^{12}. The packing fraction curve in the mass 40 region follows the general trends predicted by a formula such as that of Bohr and Wheeler, except at masses 40 and 48 where there appear to be marked discrepancies. A.

539.155

2044. Mass measurements with a magnetic time-of-flight mass spectrometer. E. E. Hays, P. I. Richards and S. A. Goudsmit. *Phys. Rev.*, **84**, 824–9 (*Nov.* 15, 1951).

A new mass spectrometer has been used to measure the time of flight of ions for a number of complete revolutions in a magnetic field. This spectrometer is especially suitable for heavy masses; the following results have been obtained so far:

S^{32}	31·983 ± 0·001	Rb^{87}	86·9295 ± 0·0020
Cl^{35}	34·9803 ± 0·0005	I^{127}	126·9415 ± 0·0025
K^{41}	40·975 ± 0·002	Xe^{129}	128·9455 ± 0·0015
Br^{79}	78·944 ± 0·001	Xe^{130}	129·945 ± 0·002
Br^{81}	80·943 ± 0·001	Xe^{131}	130·944 ± 0·002
Kr^{84}	83·938 ± 0·001	Xe^{132}	131·945 ± 0·002
Rb^{85}	84·931 ± 0·0015	Xe^{134}	133·947 ± 0·002

The precision as tabulated is estimated from the consistency between independent runs. The "probable error" is about three times smaller. A.

539.155.2 : 541.123.5

Separation of the stable isotope of sulfur 34. *See Abstr.* 2189

539.155.2 : 541.135

2045. Enrichment of Li^6 by electrolytic transfer in fused LiCl. A. Klemm. *Z. Naturforsch.*, **6a**, 512 (*Sept.*, 1951) *In German.*

Apparatus details with diagram are given for the electrolysis of fused LiCl (m.p. 614°) between two graphite electrodes. The concentration of Li^6, determined by mass-spectrometry, is 16·1 ± 0·3%, as against 7·3% in the natural mixture. H. H. Hodgson

539.155.2 : 541.135

2046. Isotopic effect of the electrolytic cation migration in halides. A. KLEMM. *Z. Naturforsch.*, **6a**, 487–8 (*Sept.*, 1951) *In German.*

The mass-effects already reported [Abstr. 3616 (1947), 4123 (1949), 2056 (1949) and abstract following] as due to electrolytic cation-migration in halides, may be computed from the equation, $\mu = -0{\cdot}15\ (2{\cdot}1\ m^{-}/2{\cdot}1m^{-} + m^{+})$, where $\mu = \frac{\Delta\omega}{\omega}\Big/\frac{\Delta m}{m}$, $\omega =$ velocity of migration, $m =$ isotopic mass, $m^{-} =$ mass of halogen atom, and $m^{+} =$ mass of metallic atom.

H. H. HODGSON

539.155.2 : 541.135

2047. Enrichment of the light zinc isotopes by electrolytic transfer in fused zinc chloride. A. KLEMM, H. HINTENBERGER AND A. LUNDEN. *Z. Naturforsch.*, **6a**, 489–94 (*Sept.*, 1951) *In German.*

At the boundary between $PbCl_2$ and $ZnCl_2$ in the cell $-/C/Pb/PbCl_2/ZnCl_2/Cl_2C/+$, the isotope distribution for Zn was displaced in favour of the lighter elements by electrolytic transfer (period, 3 days; current strength, 230 mA; current density, 4·27 A/cm²; displacement of Cl relative to Zn, 3·4 m; temperature, 650°). The separation factor 3·19 was obtained for the isotope pair Zn^{64} and Zn^{70}. The mass effect $\mu = \Delta w/w/\Delta m/m$, for the electrolytic migration velocity w of the Zn isotope in $ZnCl_2$, was found to be $\mu = -0{\cdot}079$.

H. H. HODGSON

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16

2048. Search for radiogenic krypton. E. K. GERLING AND N. V. BARANOVSKAYA. *Guide Russ. Sci. Period. Lit.* [*Brookhaven*] **4**, 203–5 (*July*, 1951).

Full translation of article abstracted in Abstr. 6399 (1951).

539.16

2049. Method of producing an electric current from radioactivity. P. E. OHMART. Letter in *J. Appl. Phys.*, **2**, 1504–5 (*Dec.*, 1951).

Experiments have shown that if a cell, made up of 2 electrochemically dissimilar electrode materials (e.g. Au and Pb) separated by a gas (e.g. air), is connected to a current-measuring device, a small continuous current flows from the more noble (e.g. Au) to the more active electrode (e.g. Pb) without an external source of voltage, when the separating gas is forcibly ionized by exposure to nuclear radiation, and this current is dependent upon the nature of the electrodes and their surfaces, the type and flux density of the energizing radiation, the type and pressure of the filling gas, and (when excited by γ-radiation) the γ-stopping power of the electrodes. The open-circuit voltages of cells with Al_2O_3 negative electrodes are for the following positive electrodes: PbO_2 plated on gold (1·34), oxidized Cu (0·975), Au plated on Cu (0·95), Ag (0·67), Cu (0·64), brass (0·64), Pb (0·2), Cr (0·18) and Zn (−0·01). There are diagrams of a coaxial type cell assembled and disassembled, of the electrometer circuit used with a coaxial cell, and of its calibration curve.

H. H. HODGSON

539.16 : 530.162

2050. Statistical fluctuation in radioactive phenomena. J. A. GRUNDL, F. G. KARIORIS AND A. G. BARKOW. *Amer. J. Phys.*, **20**, 35–7 (*Jan.*, 1952).

An experiment applicable to an intermediate laboratory course in modern physics is presented. The method is fundamentally that used in 1910 by Rutherford and Geiger, with a G.M. scaler and tape recorder replacing the scintillation technique. The experiment establishes the random nature of radioactive decay and introduces the student to the concept of statistical fluctuation.

A.

539.16.08

2051. Lamont natural radiocarbon measurements. I. J. L. KULP, H. W. FEELY AND L. E. TRYON. *Science*, **114**, 565–8 (*Nov.* 30, 1951).

Lists of ages of archaeological, marine and geological specimens estimated from the specific activity of carbon 14. Samples include wood, shells and CO_2 from sea-water; ages range from 5 to 25 000 yr.

A. H. COOK

539.16.08

2052. A comparison of three survey instruments exposed to various radiations. R. F. COWING, E. DEAMICIS AND C. K. SPALDING. *Amer. J. Roentgenol. Radium Ther.*, **66**, 961–6 (*Dec.*, 1951).

It was found that the instruments tested: The "Beckman MX-2," the "Rauland Z-100" and the "Tracerlab SU-1B," commercially available portable β- and γ-ray detectors, showed discrepancies one to another in their readings under similar conditions. Detailed tables are given, of their relative responses to scattered X-radiation, and to β- and γ-radiation from various radioisotopes. It is emphasized that thoughtful interpretation of readings taken with such meters is necessary.

D. V. MABBS

539.163.1

2053. Note on a recent measurement of the period of rubidium 87. G. CHARPAK AND F. SUZOR. *C.R. Acad. Sci.* [*Paris*] **233**, 1356–7 (*Nov.* 26, 1951) *In French.*

Criticizes the value (7·5%) for back-scattering taken by Curran, Dixon and Wilson [Abstr. 1182 (1952)]; the value (33%) obtained with S^{35} and Co^{60} using the same geometry is relatively independent of the electron energy, and with this correction, the results of Curran *et al.* give a ½-life of $(7{\cdot}6 \pm 0{\cdot}4) \times 10^{10}$ yr for Rb^{87}.

A. O. STANESBY

539.163.1.08

2054. On the determination of the decay constant of a radioactive substance. N. HOLE. *Ark. Fys.*, **3**, 471–8 (*Paper* 25, 1951).

Following an earlier paper [Abstr. 9659 (1951)] statistical methods are used to obtain the decay constant. If the exact time of every count between $t = 0$ and T is known, an estimate of the decay constant, and the exact sampling distribution and mean square deviation for this estimate are found. The case is then treated where 0 to T is divided into smaller intervals of equal length, in each of which the disintegrations are counted.

F. R. HOLT

539.163.2

2055. Some nuclear disintegrations and the nuclear shell theory. E. KONDAIAH. *Ark. Fys.*, **4**, 81–157 (*Paper* 2, 1951).

A detailed account of the determination of the decay schemes of the radioactive isotopes, Ru^{103}, Rh^{103m}, Pa^{109}, Ag^{109m}, Ce^{141}, Ce^{143}, Pr^{143}, Nd^{147}, Pm^{149}, Os^{193} is given. The decay schemes were studied using, in the main, β-spectrometer and coincidence techniques. The assignments of spins and parities are discussed on the basis of nuclear shell theory. J. HUGHES

539.163.2

2056. The spontaneous emission of neutrons by uranium. M. E. NAHMIAS. *C.R. Acad. Sci.* [*Paris*] **233**, 1185–6 (*Nov.* 12, 1951) *In French.*

Experiments similar to those of da Silveira [Abstr. 1116 (1946)] showed that the neutron component from uranium oxide, freshly separated from UX1 and UY, should be attributed to spontaneous fission of U^{235}. A. O. STANESBY

539.163.2

2057. The radioactivity of Se^{73}. F. R. SCOTT. *Phys. Rev.*, **84**, 659–65 (*Nov.* 15, 1951).

The disintegration of Se^{73} results in 4 positron groups with end-point energies and relative intensities of 1·68 MeV, 1·2%; 1·318 MeV, 87·4%; 0·750 MeV, 10·3%; and 0·250 MeV, 1·1%. Four nuclear γ-rays are observed having energies of 67·1 keV, 361 keV, 860 keV and 1·31 MeV. The K/L ratio of the internally converted electrons from the 67·1 keV and 361 keV γ-ray transitions are 7·6 and 8·6, respectively. K-capture/positron branching ratios are measured as 0·45 for the 1·318 MeV positron transitions, 1·6 for the 0·750 MeV positron transition and estimated as 6 for the 0·250 MeV positron transition. Measurement of the K Auger electrons indicates a gross K-capture/positron ratio of 0·59. A.

539.163.2

2058. Half-life and alpha-particle energy of U^{236}. A. H. JAFFEY, H. DIAMOND, A. HIRSCH AND J. MECH. *Phys. Rev.*, **84**, 785–6 (*Nov.* 15, 1951).

Several samples containing U^{236} were examined for measurement of the specific activity and the α-particle energy. The samples contained U^{234}, U^{235}, U^{236} and U^{238}, the isotopic composition being known from mass spectrometer data. The samples were "weighed" through fission counting comparison with standards containing known amounts of pure U^{235}. The α-activity due to U^{236} was determined by ionization chamber energy analysis. The same instrument was used for the energy determination. The half-life of U^{236} was found to be $2{\cdot}46\times10^{7}$ years and the α-particle energy 4·499 MeV. A.

539.163.2

2059. The decay scheme of Cu^{66}. H. RODERICK, W. E. MEYERHOF AND L. G. MANN. *Phys. Rev.*, **84**, 887–90 (*Dec.* 1, 1951).

The decay scheme of Cu^{66} has been investigated using scintillation detectors. The half-life of Cu^{66} was found to be $5{\cdot}17 \pm 0{\cdot}07$ min. The main β-ray spectrum has an end-point of $2{\cdot}7 \pm 0{\cdot}1$ MeV. $5\frac{1}{2} \pm 1\frac{1}{2}\%$ of the β-rays lead to an excited state of $1{\cdot}05 \pm 0{\cdot}03$ MeV in Zn^{66}. The half-life of this excited state is less than 5×10^{-9} sec. These results agree with the recent investigations of Friedlander and Alburger, but imply the necessity for further study of the decay scheme of Ga^{66}, which also decays to Zn^{66}. Spin, parity and shell model assignments of the pertinent states of Cu^{66}, Zn^{66} and Ga^{66} are proposed. A.

539.163.2

2060. The decay scheme of zinc-65. S. E. FURBERG. Letter in *Nature* [*Lond.*] **168**, 1005–6 (*Dec.* 8, 1951).

For Zn^{65}, the branching ratio, p, of (K-capture to the 1·11 MeV excited state of Cu^{65})/(total K-capture to excited and ground states of Cu^{65}) was determined from X-γ coincidences, using a calibrated γ-ray counter and a selective method for X-ray detection (variation of the A pressure in the X-ray counter); $p = 0{\cdot}44 \pm 0{\cdot}03$. A. O. STANESBY

539.163.2

2061. Gamma-rays and nuclear levels associated with radioisotopes of europium, erbium, and cerium. H. B. KELLER AND J. M. CORK. *Phys. Rev.*, **84**, 1079–83 (*Dec.* 15, 1951).

The energies of the conversion electrons associated with the decay of 8 radioisotopes were measured using permanent magnet-type photographic β-spectrometers. The energies of the γ-rays associated with the various activities are as follows: Eu^{152} (9·2 hr) 121·9, 344·1 keV; Er^{171} (7·5 hr) 112·8, 117·9, 125·5, 176·4, 294·5, 307·5, 419·7 keV; Ce^{137} (36 hr) 253·4 keV; Ce^{139} (140 day) 166·0, 275·2 keV; Ce^{141} (28 day) 145·7 keV; Ce^{143} (33 hr) 57·5, 290·6, 348·4 keV; Ce^{144} (300 day) 34·0, 41·3, 46·8, 53·7, 80·9, 95·0, 100·5, 134·5 keV; and Pr^{144} (17·5 min) 61·0 keV. Energy level schemes are proposed for each product nucleus. A.

539.163.2

2062. The natural radioactivity of rubidium. S. C. CURRAN, D. DIXON AND H. W. WILSON. *Phil. Mag.*, **43**, 82–92 (*Jan.*, 1952).

The mode of decay of Rb^{87} is investigated chiefly by means of a shielded proportional tube operating as a spectrometer. It is shown to consist simply of a β-transition between the ground states of Rb^{87} and Sr^{87}, the limiting energy of the particles being 275 keV and the average energy 44 keV. The spectrum, which was investigated using sources of thickness 1 mg/cm^2 and 0·128 mg/cm^2, shows no maximum, differs very considerably from that for an allowed transition and is in agreement qualitatively with that for a third forbidden transition with parity change, $\Delta I = 3$, yes. The period is found to be $\tau = 6{\cdot}15\times10^{10}$ yr. No γ-rays, X-rays or internal conversion electrons ascribable to the decay process are emitted in appreciable intensity. It is suggested that the established natural radio-elements with $Z < 80$ form a well-defined and isolated group with $\log ft = 18$ approximately. A.

539.164

2063. Determination of the alpha-energy of U^{235}. R. VESTERGAARD AND E. HAEFFNER. *Ark. Fys.*, **3**, 557–75 (*Paper No.* 36, 1951).

The energy of the α-particles from U^{235} has been determined by means of an ionization chamber connected to a linear amplifier and a 10-channel pulse

amplitude analyser. The value obtained of 3·393 ± 0·014 MeV is measured relative to the α-energies of U^{234} and U^{238}. Experimental details are given. A.

539.165/.166 : 537.542

Electron and gamma-ray spectroscopy with scintillation counters. *See Abstr.* 1078

539.165

2064. Positron spectra of certain mirror nuclei. F. I. Boley and D. J. Zaffarano. Letter in *Phys. Rev.*, **84**, 1059–60 (*Dec.* 1, 1951).

Scintillation spectrometer measurements on Mg^{23}, Si^{27}, S^{31}, Cl^{33}, K^{37} and Ca^{39} are reported.

J. J. WILKINS

539.165

2065. The beta-spectra of P^{32} and P^{33}. E. N. Jensen, R. T. Nichols, J. Clement and A. Pohm. *Phys. Rev.*, **85**, 112–19 (*Jan.* 1, 1952).

The β-spectrum of P^{32} has been examined with a thin-lens spectrometer. The maximum energy of the 14·3 day β-activity, as determined from several Kurie plots, was found to be 1·704 ± 0·008 MeV. The Kurie plots gave excellent straight lines from the maximum β-energy to about 0·26 MeV. In P samples prepared from neutron-irradiated S an additional β-activity was observed having a maximum energy of 0·26 ± 0·02 MeV and a half-life of 24·8 ± 0·5 days. This low energy β-group was also observed in P samples prepared from S and LiCl irradiated with X-rays having a maximum energy of 68 MeV. The low energy β-group was not observed in P samples prepared from S irradiated with deuterons or P irradiated with neutrons. The low energy β-group is ascribed to P^{33}. A.

539.165 : 539.166

2066. Directional correlation of successive nuclear radiations. G. Racah. *Phys. Rev.*, **84**, 910–12 (*Dec.* 1, 1951).

Using the algebra of tensor operators a closed expression is obtained for the most general case of angular correlation. The structure of the correlation function is explained by means of semiclassical considerations. A.

539.165.8

2067. Effects of the recoil on allowed β-transitions. O. Kofoed-Hansen. *Phil. Mag.*, **42**, 1411–16 (*Dec.*, 1951).

The recoil corrections to the shape of the Fermi distribution for the β-spectrum are calculated, and it is concluded that they are of the same order of magnitude as other effects, which are usually neglected. Furthermore it is shown that the observed half-life and shape of the β-spectrum of the neutron excludes any coupling in β-decay depending on nuclear v./c. terms only. A.

539.165.8

2068. Methods for measurement of average values of energy and momentum of β-recoils. O. Kofoed-Hansen. *K. Danske Vidensk. Selsk. Mat.-fys. Medd.*, **26**, 32 *pp.* (*No.* 8, 1951).

Proposed experiments are discussed, using a monatomic radioactive gas enclosed between plane parallel condenser plates. Application of an electric potential between the plates yields the average β-recoil energy [Abstr. 2555 (1948)]; a magnetic field parallel to the plates yields the average β-recoil momentum, $\langle P_R \rangle$. Combined electric and magnetic fields yield the ratio $\langle P_R \rangle - \langle P_\beta \rangle / \langle P_\beta \rangle$, where $\langle P_\beta \rangle$ is the average β-particle momentum. This ratio depends strongly on the angular correlation between β-particle and neutrino. Accuracies exceeding those of previous recoil experiments are anticipated. J. J. WILKINS

539.166

2069. Angular correlation of γ–γ cascades of Cd^{111}. H. Aeppli, H. Frauenfelder and M. Walter. *Helv. Phys. Acta*, **24**, 335–42 (*No.* 4, 1951) *In German.*

The influence of the electron shell on the angular correlation of successive nuclear radiations is discussed. The anisotropy $W(180°)/W(90°) - 1$ of the angular correlation of the γ-rays depends in the case of Cd^{111} strongly on the nature of the source and varies between 0 and − 0·20. The consequences of measurements with sources of maximum anisotropy are: It is impossible to explain the observed angular correlation of Cd^{111} assuming only pure multipole transitions. The first γ-ray has to be a mixture of electric quadrupole and magnetic dipole, the intensity ratio being $|\beta|^2/|\alpha|^2 = 0{\cdot}01 \pm 0{\cdot}003$ and the relative nuclear phase $\delta = 180°$. A.

539.166

2070. The gamma-ray spectra of K^{38} and Cl^{34}. H. K. Ticho. Letter in *Phys. Rev.*, **84**, 847–8 (*Nov.* 15, 1951).

A single 2·16 MeV line from K^{38} and lines at 1·16, 2·10 and 3·22 MeV (accuracy ± 0·03 MeV) from Cl^{34} have been observed with a scintillation spectrometer. J. J. WILKINS

539.166

2071. The second transition in the decay of Sn^{119m}. J. C. Bowe and P. Axel. *Phys. Rev.*, **84**, 939–43 (*Dec.* 1, 1951).

The photons from the second transition in Sn^{119m} were detected by using two proportional counters in coincidence. These photons have an energy of 23·8 ± 0·6 keV and could be differentiated from In X-rays only by coincidence measurements. The fraction of the second transitions which emits photons is 0·13 ± 0·03, corresponding to a total conversion of 7·3 ± 1·7. The slow neutron activation cross-section of Sn^{118} was found to be 0·01 barn. A.

539.166 : 539.172.13

2072. Internal pair spectrum from $B^{10} + d$. S. J. Bame, Jr and L. M. Baggett. *Phys. Rev.*, **84**, 891–7 (*Dec.* 1, 1951).

A magnetic lens pair spectrometer has been used to measure the energy spectrum of the internal pairs formed from the bombardment of B^{10} with deuterons. The spectrometer has been calibrated with the nuclear pair from $F^{19} + p$ with an energy of 6·05 ± 0·03 MeV. The B^{10} spectrum shows γ-rays of energies 4·43 ± 0·07, 6·51 ± 0·13, 6·75 ± 0·13, 7·34 ± 0·20 and 8·93 ± 0·13 MeV. Unresolved lines appear to exist in the region 4·5 to 5·5 MeV. The 6·51 MeV line is tentatively assigned to C^{11*} while the other lines can be attributed to B^{11*}. A.

539.166 : 537.531 : 537.542

Measurement of low energy gamma-rays with scintillation counters. *See Abstr.* 1079

539.166.74

2073. Polarization of scattered quanta. J. I. HOOVER, W. R. FAUST AND C. F. DOHNE. *Phys. Rev.*, **85**, 58–9 (*Jan.* 1, 1952).

An experimental study of the polarization effect of doubly scattered Co^{60} γ-rays as a function of the angle of scattering has been made using scintillation detectors and coincidence counting. Although there are large statistical deviations from the theoretical values at certain points, a comparison between the experimental and theoretical values indicate no serious disagreement. A.

539.166.83

2074. Threshold values of internal conversion coefficients for the *K*-shell. B. I. SPINRAD AND L. B. KELLER. Letter in *Phys. Rev.*, **84**, 1056 (*Dec.* 1, 1951).

Results of a computation using limiting cases of the formulas of Rose, *et al.* [Abstr. 7249 (1951)]. W. J. SWIATECKI

539.166.83

2075. Internal conversion angular correlations. M. E. ROSE, L. C. BIEDENHARN AND G. B. ARFKEN. *Phys. Rev.*, **85**, 5–15 (*Jan.* 1, 1952).

It is shown that the angular correlation between a conversion electron and any other radiation emitted in a double nuclear cascade can be obtained immediately if the corresponding correlation with a γ-ray replacing the conversion electron is known. This latter is known for all cases of practical interest. Specifically, if the correlation function for γ-rays and a radiation x is expanded in Legendre polynomials, the correlation function with a conversion electron replacing the γ-ray is obtained by multiplying the coefficients of each polynomial P_ν by a parameter b_ν. The case of conversion-conversion correlation, in all practical cases, is obtained from the γ–γ correlation by inserting two factors b_ν, one for each conversion electron. The coefficients b_ν are calculated relativistically and numerical results are presented for *K*-shell conversion for 12 values of Z in the range $10 \leqslant Z \leqslant 96$ and transition energies from $0{\cdot}3\ mc^2$ to $5{\cdot}0\ mc^2$ for ten multipoles (5 electric and 5 magnetic). It is pointed out that the present results apply in γ-electron correlation if the γ is a mixed multipole but the case in which the conversion transition is mixed is not computed. The angular distribution functions for electrons in a Coulomb field undergoing any type of transition are obtained in terms of the relevant matrix elements by the use of the Green function for the Dirac electron in a Coulomb field. It is also shown that the angular distribution function is obtained from matrix elements based on, not the scattered wave, but on the time-space reversed scattered wave. A.

539.166.83

2076. Internal conversion in Pr^{144}, In^{144}, Ba^{137}, and Cd^{110}. W. C. KELLY. *Phys. Rev.*, **85**, 101–3 (*Jan.* 1, 1952).

Beta-ray spectrometer measurements have been made of the internal conversion ratio α_K/α_L for four nuclear transitions. Values obtained are: $5{\cdot}3 \pm 0{\cdot}1$ for the 132 keV transition in Pr^{144}; $1{\cdot}30 \pm 0{\cdot}05$, 192 keV, In^{144}; $4{\cdot}57 \pm 0{\cdot}05$, 662 keV, Ba^{137}; and $14 \pm 2{\cdot}656$ keV, Cd^{110}. Tentative assignments of multipolarity are given. A.

539.166.835

2077. Three-photon decay of positronium. J. M. RADCLIFFE. *Phil. Mag.*, **42**, 1334 (*Nov.*, 1951).

Using Feynman methods, the lifetime of positronium for 3-photon decay has been calculated to be $1{\cdot}4 \times 10^{-7}$ sec, which agrees with Ore and Powell's calculation [Abstr. 4971 (1949)] using older methods, but disagrees with results given by Lifshits [Abstr. 1006 (1949)] and by Ivanenko and Sokolov [*Dokl. Akad Nauk, SSSR*, **61**, 51 (1948)]. R. H. DALITZ

539.167.3

2078. The slow neutron-induced radioactivities of nuclear explosions. C. E. MANDEVILLE. *J. Franklin Inst.*, **252**, 297–308 (*Oct.*, 1951).

The slow neutron-induced radioactivities of nuclear explosions have been evaluated for infinite media of filtered Schuylkill water and the earth's crust. The magnitudes of these effects are compared with the activity of the fission fragments, and the conditions under which they may be of importance are considered. It has been assumed that a gram-molecule of neutrons is liberated in the blast. A.

539.167.3

2079. Production and isolation of carrier-free radioisotopes. W. M. GARRISON AND J. G. HAMILTON. *Chem. Rev.*, **49**, 237–72 (*Oct.*, 1951).

The more important pile and cyclotron reactions yielding radioisotopes are tabulated, with such data as half-lives, energies of emissions, excitation functions and yields. The main part of the article systematically lists the various techniques available for isolation, and a table shows the applications which have been made to some 70 isotopes. More detailed descriptions of the processes employed are given in another table for most of these. Bibliography of 134 refs.

539.167.3

2080. Preparation of intense concentrated sources of P^{32}. J. LAFOUCRIÈRE. *J. Phys. Radium*, **12**, 826–7 (*Oct.*, 1951) *In French.*

The preparation of very small sources of P^{32} is described. The sources in the form of ammonium magnesium phosphate are deposited in thin-walled glass needles similar to radon needles. L. R. SHEPHERD

539.167.3

2081. Isolation of radioactive C^{11} formed by the interaction of π^- mesons on oxygen and nitrogen. A. TURKEVICH AND J. B. NIDAY. Letter in *Phys. Rev.*, **84**, 1253–4 (*Dec.* 15, 1951).

H_2O or NH_4NO_3 solutions were bombarded with 145 MeV π^- mesons and the radioactive CO and CO_2 swept out, oxidized and $CaCO_2$ precipitated and counted with a G.M. counter. Results indicate that C^{11} is produced in $\sim 2\%$ of the interactions of π^- with O^{16}. W. J. SWIATECKI

539.167.3

2082. Radioisotopes Techniques Conference—Oxford 1951. J. L. PUTMAN. *Nucleonics*, **9**, 5–16 (*Oct.*, 1951).

Report on the conference arranged by A.E.R.E. Harwell and held in Oxford, July 16–20, 1951, dealing with medical, biochemical, agricultural and industrial uses of radioisotopes. Short summaries of 50 papers are given. L. R. SHEPHERD

539.167.3 : 778.33

2083. Deuteron activation and autoradiography as coupled techniques in tracer experiments. K. M. Laing, R. E. Jones, D. E. Emhiser, J. V. Fitzgerald and G. S. Bachman. *Nucleonics*, **9**, 44–6 (*Oct.*, 1951).

The penetration of Na from molten glass into refractory materials lining melting tanks and furnaces has been studied, by bombarding specimens of the materials with 4–5 MeV deuterons and taking autoradiographs to determine the location and concentration of Na^{24} so produced. L. R. SHEPHERD

539.169 : 541.15

2084. New methods of studying Szilard–Chalmers processes applied to sodium chloroiridiate. U. Croatto, G. Giacomello and A. G. Maddock. *Ric. Sci.*, **21**, 1788–90 (*Oct.*, 1951) *In Italian.*

The Szilard–Chalmers rupture of sodium chloroiridiate gives 34% separable Ir^{194} activity. Separation may be achieved by co-deposition on ferric hydroxide or by removal of the unchanged chloroiridiate as the very sparingly soluble potassium or ammonium salts. It is shown that the products of the recoil can be also separated by electrolysis, ion-exchanger or paper chromatography. The latter method indicates that two distinct iridium species may be formed by the recoil process. A.

NUCLEAR REACTIONS 539.17

539.17

2085. Experiments on the high-energy nucleons and quanta. J. Cockcroft. *Nature* [*Lond.*] **168**, 1060–4 (*Dec.* 22, 1951).

Text of a lecture surveying briefly high-energy nuclear and meson physics, illustrated by discussion of recent Harwell experiments on nucleon scattering, on nuclear disintegrations and production of new isotopes, and on the photo-plate study of γ-disintegration of light nuclei. R. H. DALITZ

539.172

2086. The interaction of π-mesons with carbon nuclei. A. M. Shapiro. Letter in *Phys. Rev.*, **84**, 1063–4 (*Dec.* 1, 1951).

About 10^4 traversals of $\pi^{\pm}$-mesons ($\sim$ 48 MeV) through 0·520 g/cm^2 carbon plates were photographed in a cloud chamber and classified as nuclear interactions and elastic scatterings. The observed smallness of the total cross-section suggests that, assuming ps. scalar mesons, the coupling is ps. vector. W. J. SWIATECKI

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 1935–40

539.172.11

2087. γ-rays in the reaction Be^9 (α, n)C^{12}. K. P. Artemov and N. A. Vlasov. *Guide Russ. Sci. Period. Lit.* [*Brookhaven*] **4**, 235–6 (*Aug.*, 1951).

Full translation of article abstracted in Abstr. 6450 (1951).

539.172.11

2088. The alpha-particle disintegration of beryllium. W. O. McMinn, M. B. Sampson and V. K. Rasmussen. *Phys. Rev.*, **84**, 963–6 (*Dec.* 1, 1951).

The disintegration of Be^9 by 21·7 MeV α-particles has been studied with observations of the emitted particles made at various angles. Q-values of $-6·92$, $-7·87$, $-8·57$ and $-10·74$ MeV were found for the $Be^9(\alpha, p)B^{12}$ reaction giving levels in B^{12} at 0·95, 1·65 and 3·82 MeV. Two groups of deuterons from $Be^9(\alpha, d)B^{11}$ were found giving a level in B^{11} at 2·18 MeV. A third group, if assigned to this reaction would give a level in B^{11} at 0·65 MeV. The inelastic scattering $Be^9(\alpha, \alpha')Be^{9*}$ gives a level in Be^9 at 2·63 MeV. A.

539.172.11

2089. Excited states of F^{19} from $O^{16}(\alpha, p)F^{19}$. M. L. Bullock and M. B. Sampson. *Phys. Rev.*, **84**, 967–8 (*Dec.* 1, 1951).

Oxygen gas has been bombarded with 20·6 MeV α-particles, and the resulting proton groups have been studied using a proportional counter. The energies of the proton groups were measured by their range in aluminium. Q-values of $-8·08$, $-9·44$, $-10·75$ and $-12·00$ MeV were obtained giving levels in F^{19} at 1·36, 2·67 and 3·92 MeV. A.

539.172.11

2090. A NaI (Tl) scintillation spectrometer study of proton gamma-ray coincidences. R. C. Allen, J. E. May and W. Rall. *Phys. Rev.*, **84**, 1203–6 (*Dec.* 15, 1951).

A proton γ-ray coincidence study of the $Al^{27}(\alpha, p)Si^{30}$ reaction has been made using a NaI(Tl) scintillation spectrometer. The decay scheme of the excited states of Si^{30} has been established and the energies of the γ-rays have been measured. The decay of the third excited state was found to be a double cascade process: from the third to the second to the ground state, and from the third to the first to the ground state. The γ-ray energies in the former process were determined to be $1·28 \pm 0·06$ MeV and $3·66 \pm 0·15$ MeV. The energies of both the γ-rays in the latter transition were found to be between 2·2 and 2·7 MeV. Measurements on the second excited state showed that the decay was direct to the ground state, the energy of the γ-rays being $3·63 \pm 0·15$ MeV. The γ-ray energy from the first excited state was established to be $2·32 \pm 0·05$ MeV. A.

539.172.11

2091. High energy neutron collisions with helium. C. Swartz. *Phys. Rev.*, **85**, 73–7 (*Jan.* 1, 1952).

A cloud-chamber investigation has been made of high energy neutron collisions with He. 377 elastic recoils and 126 disintegrations have been observed. Two groups are selected from the elastic collisions according to the energy of the incident neutron, estimated from the appearance and δ-ray structure of the recoiling α-particle. The scattering by neutrons in the 10- to 30-MeV range appears roughly isotropic in the centre of mass, while neutrons with energy greater than 50 MeV are scattered strongly in the forward direction. An absence of evidence for neutrons scattered at very small angles is described. This seems different from that predicted by one theory of neutron–helium collisions. A.

539.172.13

2092. Excitation functions and cross-sections of the (p, n) reaction. II. J.-P. BLASER, F. BOEHM, P. MARMIER AND P. SCHERRER. *Helv. Phys. Acta*, **24**, 441–64 (*No.* 5, 1951) *In German.*

For Pt I, see Abstr. 3763 (1951). Absolute cross-sections and excitation functions have been investigated for 60 nuclei and isomers of the elements Ni, Ga, As, Se, Br, Rb, Sr, Y, Zr, Nb, Mo, Ru, Rh, Pd, Cd, In, Sn, Sb, Te, I, Cs, Ba, La, Ce, Pr, Nd and Gd. Cross-sections for an incident proton energy of 6·7 MeV are plotted as function of Z and compared with Weisskopf's new theoretical values. r_0 is shown to be independent of Z and to have a mean value of $1{\cdot}5\times10^{-13}$ cm. The method of stacked foils is used for excitation functions. The nuclei Ni^{60}, Zr^{90} and Sn^{116} give extremely low cross-sections. These low values may be due to the filling up of both proton and neutron shells, if one considers 32, 40 and 66 to be "semi-magic" numbers indicating the filling up of a subshell. Nb^{93} also shows low (p, n) cross section. Its excitation function has been measured and possible causes for this anomaly are discussed. A.

539.172.13

2093. Excitation functions of the (p, n) reaction. III. J.-P. BLASER, F. BOEHM, P. MARMIER AND P. SCHERRER. *Helv. Phys. Acta*, **24**, 465–82 (*No.* 5, 1951) *In French.*

For Pt II, see preceding abstract. The excitation functions on Li^7, B^{11}, C^{13}, O^{18}, F^{19}, Na^{23}, $Mg^{25/26}$, Al^{27} and Cl^{37} have been measured for proton energies ranging from the threshold up to 6·8 MeV. Three different methods are used according to the various radioactivities produced. The levels excited in the compound nuclei and the absolute cross-sections are given and discussed. A.

539.172.13

2094. Neutron emission from nuclei excited by high energy protons. D. M. SKYRME AND W. S. C. WILLIAMS. Letter in *Phil. Mag.*, **42**, 1187–90 (*Oct.*, 1951).

Evaporation neutrons from C and W targets bombarded in a 171 MeV (max.) cyclotron proton beam were investigated with photographic plates. Results agree reasonably with theory, though from C more high energy neutrons were detected than was expected. F. R. HOLT

539.172.13

2095. The high energy spallation products of copper. R. E. BATZEL, D. R. MILLER AND G. T. SEABORG. *Phys. Rev.*, **84**, 671–83 (*Nov.* 15, 1951).

Nuclear reactions induced in elemental Cu by irradiation with charged particles accelerated to energies in the 100-MeV range have been studied, and the reaction products cover a range from the region of the target nucleus to a region which is removed from the target nucleus by as many as 40 or more nucleons. The yields of the various products were measured, and the results show that a large majority of the products result from reactions in which only a fraction of the total energy of the incident particle is left with the nucleus. The distribution of the amounts of the reaction products is in agreement with a picture of high-energy nuclear reactions involving nuclear transparency and the idea that the nuclear reactions involve excitation following collisions and energy transfers between the individual nucleons in the impinging particle and the individual nucleons in the target nucleus. The results include recent work on the nuclear reactions induced by 340-MeV protons and some earlier qualitative work on the nuclear reactions induced by 190-MeV deuterons and 190- and 380-MeV He ions. A.

539.172.13

2096. Elastic scattering of protons from Mg^{24}. F. P. MOORING, L. J. KOESTER, JR, E. GOLDBERG, D. SAXON AND S. G. KAUFMANN. *Phys. Rev.*, **84**, 703–9 (*Nov.* 15, 1951).

The differential scattering cross-section has been determined for protons scattered elastically from Mg^{24} at a laboratory angle of 164° ± 5°. The targets consisted of thin $Mg^{24}F_2$ films evaporated on to thick graphite. Protons scattered elastically from Mg^{24} were selected by a 90° magnetic analyser and were counted by a proportional counter. At least 9 anomalies occur in the cross-section between 0·40 MeV and 3·95 MeV, indicating the excitation of 9 levels of the compound nucleus, Al^{25}. At several of the resonances, competing reaction cross-sections have been shown to be relatively small. A.

539.172.13

2097. Electrostatic analysis of nuclear reaction energies. R. M. WILLIAMSON, C. P. BROWNE, D. S. CRAIG AND D. J. DONAHUE. *Phys. Rev.*, **84**, 731–6 (*Nov.* 15, 1951).

Electrostatic analysers for incident and product particles of nuclear reactions have been employed to measure the following ground state Q values: $Li^6(p, He^3)\ \alpha$ (4·024 ± 0·005 MeV), $Li^7(d, p)\ Li^8$ (− 0·192 ± 0·001 MeV), $Be^9(p, d)Be^8$ (0·558 ± 0·002 MeV), $Be^9(p, \alpha)Li^6$ (2·123 ± 0·004 MeV), $Be^9(d, Li^7)(\alpha 7{\cdot}159 \pm 0{\cdot}009$ MeV). Absolute energy calibration was based on a $Li^7(p, n)Be^7$ threshold of 1·882 ± 0·002 MeV. No systematic differences appear between these data and other measurements employing magnetic analysis and other absolute energy calibrations. Data taken on the inelastic scattering of both protons and deuterons from Li^7 result in a value of 0·4780 ± 0·0012 MeV for the first excited level of Li. This figure overlaps previous γ-ray measurements based on the 411·2-keV γ from Au^{198}. The yield of alphas from deuteron bombardment of T absorbed in Zr showed that the number of absorbed T atoms decreased rapidly near the surface of the Zr. From this data, a lower limit of 17·578 − 0·030 MeV may be given the $T(d, \alpha)n$ Q value. A.

539.172.13

2098. Energy release in the disintegration of Be^8. R. R. CARLSON. *Phys. Rev.*, **84**, 749–57 (*Nov.* 15, 1951).

Thin Be targets were bombarded with 400-keV protons and the energy spectra of the particles given off at 90 degrees to the beam direction were observed with a cylindrical electrostatic analyser. The Be was evaporated on to a Ni backing which was thin enough to confine the elastically scattered protons to

a narrow energy range. At energies below that of the elastically scattered protons, peaks were observed in the energy spectra which corresponded to the maximum α-particle energy in the continuous energy distribution of α-particles resulting from the break-up of Be^8. The position of these maxima give a value for the energy release in the disintegration $77{\cdot}5 \pm 4$ keV. A.

539.172.13

2099. π^+-Meson production cross section as a function of atomic number. D. Hamlin, M. Jakobson, J. Merritt and A. Schulz. Letter in *Phys. Rev.*, **84**, 857–8 (*Nov.* 15, 1951).

This was measured using crystal detectors for 53 ± 4 MeV mesons produced at $0° \pm 7°$ to a 340 MeV proton beam impinging on C, Al, Fe, Cu, Ag and Pb. The cross-section per nucleon decreases with A. W. J. Swiatecki

539.172.13

2100. Proton bombardment of the lithium isotopes. S. Bashkin and H. T. Richards. *Phys. Rev.*, **84**, 1124–9 (*Dec.* 15, 1951).

Thin targets of ordinary Li have been bombarded by protons over the energy range 0·4 MeV to 3·6 MeV. Observations of the magnetically analysed reaction and scattered particles were made at 164° to the incident beam. Differential cross-section curves were obtained for protons scattered elastically and inelastically from Li^7, elastically from Li^6, and for the He^4 and He^3 particles from the $Li^6(p, \alpha)He^3$ reaction. The Li^6 data show an excited state in Be^7 at about 7·2 MeV and also a lower and very broad state. Possible correspondence to levels in the mirror nucleus Li^7 is discussed. The protons scattered inelastically from Li^7 do not show any resonances above $E_p = 1{\cdot}5$ MeV. The Li^7 elastic scattering cross-section has maxima at proton energies of 1·05 MeV, 1·88 MeV and 2·06 MeV. A.

539.172.13

2101. The reaction $Mn^{55}(p, n)Fe^{55}$. J. J. G. McCue and W. M. Preston. *Phys. Rev.*, **84**, 1150–4 (*Dec.* 15, 1951).

The neutron spectrum from the reaction $Mn^{55}(p, n)Fe^{55}$ has been examined from the threshold to a proton bombarding energy of 2·85 MeV. The reaction threshold was found to be $1{\cdot}020 \pm 0{\cdot}010$ MeV. Many resonances were found in the neutron yield; these correspond to excited states of Fe^{56}. A limited region was studied with a resolution width of about 2 keV, and an upper limit of 4·5 keV was found for the average observed level spacing. A.

539.172.13

2102. The thick target yield of the reaction $C^{12}(p, \gamma)N^{13}(\beta^+)C^{13}$. J. D. Seagrave. *Phys. Rev.*, **84**, 1219–25 (*Dec.* 15, 1951).

The yield of N^{13} from a thick carbon target bombarded with protons of energy up to 2·5 MeV has been studied by detecting annihilation quanta with a scintillation crystal. Resonances at 0·45 and 1·70 MeV are confirmed, and independent values are obtained for their relative and absolute intensities. A.

539.172.13

2103. The cross section for the radiative capture of protons by C^{13} at 129 keV. E. J. Woodbury and W. A. Fowler. *Phys. Rev.*, **85**, 51–6 (*Jan.* 1, 1952).

The cross-section for the capture of protons by C^{13} at 129 keV is $\sigma = 5 \pm 1 \times 10^{-33}$ cm². This measurement was made possible through the use of a scintillation counter that had an over-all detection efficiency of 8·7%, and a pulsed ion source that had a peak proton current capability of one milliampere. A rough analysis of the radiation shows that 80% is due to the transition to the ground state of N^{14}, while the exact nature of the remaining 20% was not determined. A.

539.172.13 : 537.534.744

Proton polarization by bombardment of He. *See Abstr.* 1883

539.172.13

2104. Angular distributions of the neutron groups from the reaction $^{12}C(d, n)^{13}N$. F. A. El-Bedewi, R. Middleton and C. T. Tai. Letter in *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1055–6 (*Nov.*, 1951).

The groups correspond to transitions to the ground state and two excited states of N^{13}. Spin and parity of these states are deduced on Butler's theory [Abstr. 8973, 3016 (1951)].

539.172.13

2105. Differential cross section of the reaction $He^3(d, p)He^4$ at 10·2-MeV bombarding energy and search for excited state in He^4. J. C. Allred. *Phys. Rev.*, **84**, 695–9 (*Nov.* 15, 1951).

The differential cross-section of the reaction $He^3(d, p)He^4$ has been measured by means of a photographic technique. The cross-section shows a high degree of asymmetry and is quite similar to that previously measured for the $T(d, n)He^4$ differential cross-section at 10·5 MeV. This similarity suggests equality of p–p and n–n forces. Observations of the short-range particles from bombardments of He^3 and T gases under identical conditions permit the assignment of upper limits for the reaction $He^3(d, p')He^{4*}$. At a laboratory angle of 90°, the cross-section is less than $0{\cdot}2 \times 10^{-27}$ cm² for an excited state below 20·9 MeV. A.

539.172.13

2106. Nuclear excitation functions, $Se^{82}(d, 2n)Br^{82}$ and $Br^{81}(d, p)Br^{82}$. J. A. Miskel and A. C. Wahl. *Phys. Rev.*, **84**, 700–2 (*Nov.* 15, 1951).

The cross-section of the $Se^{82}(d, 2n)Br^{82}$ reaction was found to rise rapidly with deuteron energy, increasing from zero between 3 and 4 MeV to 0·93 barn at 9·7 MeV. The cross-section of the $Br^{81}(d, p)Br^{82}$ reaction was redetermined around 9 MeV, which is near the maximum of the curve, and was found to be 0·17 barn. A.

539.172.13

2107. The $Al^{27}(d, p)Al^{28}$ and $Al^{27}(d, d')Al^{27}$ reactions. K. K. Keller. *Phys. Rev.*, **84**, 884–6 (*Dec.* 1, 1951).

A large heavy-particle magnetic spectrometer was used to study the proton and deuteron groups from the deuteron bombardment of a thin Al foil. Charged particles emitted at 90 degrees with respect to the incident deuteron beam were analysed by momentum in an annular-shaped magnetic field. Groups of

protons and deuterons correspond to excited states in Al^{28} and Al^{27}, respectively. Fifteen groups of protons from the reaction $Al^{27}(d, p)Al^{28}$ were observed. Their Q values were 5·53, 4·49, 3·95, 3·36, 3·01, 2·06, 1·55, 0·70, 0·37, −0·27, −0·60, −0·84, −1·37, −1·86 and −2·98 MeV. The elastically scattered deuterons and five groups of inelastically scattered deuterons were also observed. Their Q values were 0, −0·97, −2·39, −3·17, −4·74 and −5·76 MeV. A.

539.172.3

2108. The deuteron photo-disintegration by the lithium gamma-rays. H. WÄFFLER AND S. YOUNIS. *Helv. Phys. Acta*, **24**, 483–507 (*No.* 5, 1951).

The photo-disintegration of the deuteron by the γ-rays arising from the reaction $Li^7(p, \gamma)Be^8$ ($h\nu$ = 17·6 and 14·8 MeV) has been investigated using the photographic plate technique. The angular distribution of the emitted photoprotons as well as the total cross-section of the reaction have been determined. From a total of 2 000 observed tracks for both γ-lines together: (1) The angular distribution in the centre-of-mass system is of the form $0{\cdot}12 + \sin^2\Theta\,(1 + 0{\cdot}24\cos\Theta)$. It confirms within the limits of error the retardation effect calculated by Marshall and Guth. (2) The total cross-section has the value $\sigma_{tot} = (8{\cdot}34 \pm 1{\cdot}0)\times10^{-28}$ cm². A discussion of these results from the point of view of the meson theory of nuclear forces is given. A.

539.172.3

2109. The photodisintegration of ^{10}B into neutron, proton and two α-particles. M. J. BRINKWORTH AND E. W. TITTERTON. Letter in *Phil. Mag.*, **42**, 1191–2 (*Oct.*, 1951).

A cross-section of $(3{\cdot}2 \pm 1{\cdot}3)\times10^{-28}$ cm² for $Li^7(p, \gamma)$ radiation is reported. J. J. WILKINS

539.172.3

2110. The reaction $^{12}C(\gamma, 3\alpha)$ and a 16·9 MeV level of ^8Be emitting alpha-particles. J. J. WILKINS AND F. K. GOWARD. Letter in *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1056–7 (*Nov.*, 1951).

See Abstr. 3774 (1951). Emulsions were exposed to 70 MeV bremsstrahlung. A second maximum in cross-section was found at 27 MeV. Of 60 stars with $E_\gamma \geqslant 26$ MeV, 52 involved transition through a 16·9 MeV excited level of Be^8.

539.172.3

2111. A phenomenological treatment of photomeson production from deuterons. G. F. CHEW AND H. W. LEWIS. *Phys. Rev.*, **84**, 779–85 (*Nov.* 15, 1951).

A phenomenological treatment of charged and neutral photomeson production from deuterons is presented which is independent of the details of the meson theory. It is shown that an experimental comparison of the deuteron and proton cross-sections can be used to determine the nucleon spin flip probability. A.

539.172.3

2112. Theory of nuclear photoprocesses. R. G. SACHS. Letter in *Phys. Rev.*, **84**, 845 (*Nov.* 15, 1951).

Elucidation of the zero effect of exchange currents in electric dipole transitions. J. J. WILKINS

539.172.3

2113. The photo-electric disintegration of three- and four-particle nuclei. J. C. GUNN AND J. IRVING. *Phil. Mag.*, **42**, 1353–68 (*Dec.*, 1951).

The two-particle and complete photoelectric disintegration cross-sections for three- and four-particle nuclei are calculated, using Gaussian and new exponential wave-functions. By suitable adjustment of a scale constant photodisintegration, curves can be found with the maximum cross-section at any chosen energy above the threshold. For a given position of the maximum the Gaussian wave functions require a bigger nucleus than the exponential, and then give a larger maximum cross-section. The theoretical predictions are concerned with the small amount of experimental data available, mainly from the inverse processes of p-D and p-T capture. The exponential wave functions appear to fit more reasonably with this evidence. A.

539.172.3

2114. Photoproton and photoneutron relative yields. R. K. SHELINE. Letter in *Phys. Rev.*, **84**, 1064 (*Dec.* 1, 1951).

Measurements on Mg and Si are reported and shown to be consistent with the theory of Marquez [Abstr. 4725 (1951)]. J. J. WILKINS

539.172.3

2115. Photonuclear cross sections in aluminum and magnesium. L. KATZ AND A. G. W. CAMERON. *Phys. Rev.*, **84**, 1115–19 (*Dec.* 15, 1951).

Cross-section curves have been measured as functions of photon energy for the reactions $Al^{27}(\gamma, n)Al^{26}$, $Mg^{24}(\gamma, n)Mg^{23}$, $Mg^{25}(\gamma, p)Na^{24}$, and $Mg^{26}(\gamma, p)Na^{25}$. These curves exhibit the peaked shape characteristic of photonuclear reactions, the maximum cross-sections being 8·1, 9·8, 14·8 and 19·3 millibarns respectively. The (γ, p) peak positions occur about 2 MeV higher than those of the (γ, n) reactions and their cross-sections as indicated above are considerably larger. It is shown that these peaked shapes result from a peaking of the photonuclear absorption cross-sections. The larger values of the (γ, p) peak positions and cross-sections may be explained as resulting from a direct interaction between high-energy photons and nuclear protons. A.

539.172.3

2116. The angular distribution of protons in the photo-disintegration of the deuteron. K. PHILLIPS. *Phil. Mag.*, **43**, 129–33 (*Jan.*, 1952).

Using a thin heavy wax target the angular distribution of photo-protons has been observed in photographic plates, for the energy range 6 to 15 MeV. A.

539.172.3 : 536.48

2117. A liquid hydrogen target. L. COOK. *Rev. Sci. Instrum.*, **22**, 1006–8 (*Dec.*, 1951).

A description is given of a target in which liquid H was bombarded with X-rays from the Berkeley synchrotron. The liquid H, in a stainless steel flask, was surrounded by an evacuated jacket containing a heat shield maintained at the temperature of liquid N. The liquid level was indicated by a counterweighted float system. A.

539.172.4

2118. Total cross-section of the elements Be, C and O for neutrons in the energy range from 1·9 to 3·8 MeV. R. Ricamo and W. Zünti. *Helv. Phys. Acta*, **24**, 419–40 (*No.* 5, 1951) *In German.*

The investigation was made by measuring the transmission of C, Be and BeO samples. Deuterons falling on a thin heavy-ice target provided the nearly monochromatic neutrons. The properties of an anthracene crystal as an efficient fast neutron detector are discussed. An analysis is made of the sources of error in the transmission method. New sharp resonances were found in the cross-section of carbon at 2·09 and 2·95 MeV, and in the cross-section of oxygen at 1·89 and 3·75 MeV, as well as a pronounced negative resonance at 2·35 MeV. A tentative explanation of this phenomenon is given. A.

539.172.4

2119. Measurements of the cross-sections of the $N^{14}(n, \alpha)B^{11}$ and $N^{14}(n, p)C^{14}$ processes with monochromatic D–D neutrons. W. Bollmann and W. Zünti. *Helv. Phys. Acta*, **24**, 517–50 (*No.* 5, 1951) *In German.*

The variation of the cross-sections reactions was measured with neutrons in the energy range from 2 to 3·6 MeV. (n, α) resonances were found at neutron energies of 2·26, 2·56 and 2·75 MeV, and (n, p) resonances at 2·26 and 2·80 MeV. Different methods of the determination of Q-values are discussed. A description of a simple photographic pulse-height spectrometer is also included. A.

539.172.4

2120. Radioactivities of silver by irradiation with fast neutrons from the Ra + Be-source. N. K. Saha and K. Gopalakrishnan. *Proc. Nat. Inst. Sci. India*, **17**, 301–9 (*July–Aug.*, 1951).

Neutrons from a 100 mgm Ra + Be source were used to irradiate the Ag cathode of a G.M. counter and the 22 sec, 2·3 min and 24 min periods of radio Ag were studied. The 24 min period activity is due to Ag^{106} produced by $Ag^{107}(n, 2n)Ag^{106*}(\beta^+)Pd^{106}$. The 2·3 min period due to Ag^{108} can be produced by the simple capture of slow neutrons in Ag^{107} or by $Ag^{109}(n, 2n)Ag^{108*}(\beta^-)Cd^{108}$. From the observations on the relative intensities of the periods developed under different conditions of irradiation it is proved qualitatively that: (1) The 24 min activity (Ag^{106}) is produced only by very fast neutrons towards the upper limit of the Ra + Be neutron energy spectrum. (2) About 5% of the usually observed 2·3 min activity with neutrons slowed down by 10 cm of paraffin wax is due to the fast neutrons transmitted by the wax. (3) The cross-sections of the 2·3 min activity for the fast and slow neutrons are roughly in the ratio 1 : 14. (4) The relative yield of the 24 min process to the 2·3 min process produced by fast neutrons is roughly 1 to 42. (5) Roughly about 73% of the neutrons emerging from the 10 cm wax cylinder are slow neutrons (producing the 2·3 min period activity of Ag). A.

539.172.4

2121. Calculation of yields in multiple neutron capture processes. R. F. van Wye and J. G. Beckerley. *Nucleonics*, **9**, 17–21 (*Oct.*, 1951).

A method is given for calculating the amount of a given isotope present, when a heavy element is irradiated by neutrons in a pile. It is assumed that the isotope can be formed from others by β-decay or neutron capture and can be destroyed by fission, β-decay or neutron capture. The quantities of Th^{233}, Th^{234}, Pa^{233} and Pa^{234} formed during the irradiation of Th^{232} in thermal neutron fluxes of 10^{12}, 10^{13} and 10^{14} n/cm²/sec are calculated by way of example. L. R. Shepherd

539.172.4

2122. Total cross section of nitrogen for fast neutrons. C. H. Johnson, B. Petree and R. K. Adair. *Phys. Rev.*, **84**, 775–8 (*Nov.* 15, 1951).

The total neutron cross-section of N has been measured for neutron energies from 0·15 to 1·45 MeV. Resonances in the total cross-section are observed at 0·433, 0·640, 1·00, 1·12, 1·35 and 1·45 MeV. The second, third and last of these resonances correspond in energy to resonances observed in the disintegration of N. Application of the nuclear dispersion theory indicates that the resonances at 0·64 and 1·00 MeV are caused by neutrons of zero orbital angular momentum forming compound states of spin $\frac{1}{2}$ and $\frac{3}{2}$, respectively. An experiment is proposed which would, in conjunction with these measurements, determine the relative parity of C^{14} and N^{14}. A.

539.172.4

2123. Resonance-region neutron spectrometer measurements on silver and tungsten. W. Selove. *Phys. Rev.*, **84**, 869–76 (*Dec.* 1, 1951).

A high-speed rotating-shutter spectrometer has been built for making slow neutron measurements in the resonance region, using a neutron "pile" as a source. One of the principal advantages of the new apparatus is that comparatively small samples are required—typically less than one gram. Thus measurements can be made on many comparatively rare materials, such as certain separated isotopes. Measurements are reported here on Ag and W. These measurements were made with an effective resolution in reciprocal velocity somewhat better than 1·0 microsecond/meter at high energies. In Ag, the measurements show clearly resolved resonances at 5, 16, 30, 41 and 53 eV, and numerous unresolved resonances at higher energies. The constants of the 5 eV resonance are $E_r = 5{\cdot}17 \pm 0{\cdot}08$ eV, $\sigma_0 = 12\,000 \pm 1\,500$ barns (10 000 barns for metallic Ag at room temperature), $\Gamma = 0{\cdot}17 \pm 0{\cdot}02$ eV, $\Gamma_n \simeq 0{\cdot}011$ eV. The W work includes measurements on separated-isotope samples of the 4 major isotopes. The resonance-level spacings observed in these isotopes are: 10 to 30 eV in 182, about 20 eV in 183, perhaps 100 eV in 184 and several hundred eV in 186. A.

539.172.4

2124. Neutron stars in krypton. J. K. Bøggild and F. H. Tenney. Letter in *Phys. Rev.*, **84**, 1070–1 (*Dec.* 1, 1951).

The plot of 200 stars (photographed in a cloud chamber) *v.* prong number is similar to previous results for O, Ne and A. The α to proton ratio is 0·21 (cf. 2·1, 1·4, 0·9 for O, Ne, A). W. J. Swiatecki

539.172.4

2125. Total neutron cross sections of cobalt, manganese, and molybdenum. W. F. STUBBINS. *Phys. Rev.*, **84**, 902–5 (*Dec.* 1, 1951).

The total neutron cross-sections of Co, Mn and Mo were measured with a neutron energy resolution of ± 6 keV using neutrons from the Li(p, n)Be reaction with an electrostatic accelerator. Co and Mn were examined from 80 to 1 000 keV. Both their cross-sections fluctuate rapidly at low energies and level off and decrease slowly to about 3 barns at 750 keV. Mo was measured from 10 to 1 230 keV, and its cross-section is about 9 barns to 250 keV and decreases uniformly to 6 barns at 1 230 keV. A.

539.172.4

2126. Radiative capture of thermal neutrons by Li^7. R. G. THOMAS. Letter in *Phys. Rev.*, **84**, 1061–2 (*Dec.* 1, 1951).

The observed largeness of the cross-section [Abstr. 187 (1948)] is shown to be explainable as the result of a large extra-nuclear contribution to the matrix element of the dipole moment. W. J. SWIATECKI

539.172.4 : 539.185

2127. A theoretical calculation of the inelastic scattering of 90-MeV neutrons by deuterons. G. F. CHEW. *Phys. Rev.*, **84**, 710–16 (*Nov.* 15, 1951).

The number and distribution of disintegration protons to be expected from the $H^2(n, p)$ reaction at 90 MeV incident neutron energy is calculated phenomenologically. No assumption about the character of nuclear forces is required, the impulse approximation allowing direct use of high energy n–p and p–p scattering data. Agreement with experiment is satisfactory, there being no evidence for a difference between n–n and p–p interactions. A.

539.172.4

2128. Total charges of fission fragments as functions of the pressure of the stopping gas. N. O. LASSEN. *K. Danske Vidensk. Selsk. Mat.-fys. Medd.*, **26**, 19 *pp.* (*No.* 12, 1951).

Extension of earlier measurements [Abstr. 8210 (1951)] to higher gas pressures. With increasing gas pressure the charges of the light fragments tend to the values 19e and 18e in H_2 and A respectively.

J. HUGHES

539.172.4

2129. Instrumentation and control of reactors. J. D. TRIMMER AND W. H. JORDAN. *Nucleonics*, **9**, 60–8 (*Oct.*, 1951).

The principles of reactor kinetics are outlined. Effects of fission product poisons, modification of spatial neutron distribution by control rods, temperature changes of reactivity and the presence of a closed coolant circuit with heat exchanger are discussed briefly. L. R. SHEPHERD

539.172.4

2130. The pile oscillator method applied to the comparison of graphite samples. A. ERTAUD, V. RAIEVSKI AND D. BRETON. *J. Phys. Radium*, **12**, 784–8 (*Oct.*, 1951) *In French.*

The sample is oscillated in the graphite reflector of a pile and the resultant oscillation of the current in a BF_3 chamber placed in the vicinity of the centre of oscillation is measured. This current oscillation is the resultant of two effects, the one representing the overall variation in pile power which lags about 30° behind the mechanical oscillation, and the other a purely local variation in the region of the sample which is in phase with the mechanical oscillation. It is found that the value of the phase difference between mechanical and current oscillations is sensitive to the ratio of absorption to scattering cross-section in the sample. Differences in capture cross-sections between two samples equivalent to 0·1 p.p.m. of boron can be detected by observing the differences in phases. Small differences (e.g. 3%) in length or weight of a sample lead to negligible errors in the observed phase change which is also insensitive to pile power.

L. R. SHEPHERD

539.172.4

2131. An experimental study of the kinetics of the Châtillon pile. A. ERTAUD, R. BEAUGÉ, H. FAUQUEZ AND L. VAUTREY. *J. Phys. Radium*, **12**, 17 A–25 A (*Oct.*, 1951) *In French.*

The variation of reactivity ($\varepsilon = k_{eff} - 1$) of the Châtillon uranium/heavy water pile, with control rod position, heavy water level and temperature has been studied using an adaption of the Nordheim formula relating ε to rate of increase of pile power. It was found possible, over a fairly wide range of variations, to relate changes in ε with changes in positions, p_1 and p_2, of the control rods, changes in heavy water level N and in pile temperature T by a linear expression $\Delta\varepsilon = 0{\cdot}58\ (\Delta p_1 + \Delta p_2) + 5\,\Delta N + 24\,\Delta\theta$. ($p_1$, p_2 and N in mm, θ in deg C, $\Delta\varepsilon$ in parts per 10^5). The "pile temperature" refers to the mean of two thermocouple measurements, one made just inside the Al can of a UO_2 fuel element, the other in the heavy water midway between two elements. The range of linearity of $\Delta\varepsilon$ with $\Delta\theta$ was 25° − 45°C, and with Δp_1 or Δp_2 about 500 mm movement of either control rod. L. R. SHEPHERD

ATOM AND MOLECULE BEAMS . MESONS NEUTRONS 539.18

539.18

2132. On the scattering of mesons in a 2 cm lead plate. A. B. SAHIAR. *Proc. Indian Acad. Sci. A*, **34**, 201–13 (*Sept.*, 1951).

Photographs of more than a thousand particles traversing a 2 cm lead block inside a Wilson cloud chamber, were taken at sea level (Bombay). Coulomb and nuclear scatterings of particles capable of going through 5, 15, 25 and 35 cm of lead were studied. The experimental scattering distributions have been compared, and found to be in fairly good agreement with the theoretical distributions calculated by assuming Williams' scattering distributions, and Wilson's energy spectrum measurements at London. A lower limit of the order of 2 to 3×10^{-28} cm^2 per nucleon, for the nuclear scattering cross-section of mesons has been indicated. This value is in fairly good agreement with the values obtained by most of the experimental workers. The number of large angle scatterings observed is not sufficiently large to study the variation of the nuclear scattering cross-section with energy. A.

539.18

2133. Review of the principal properties of mesons. P. Benoist-Gueutal and J. Ratier. *J. Phys. Radium*, **12**, 873–6 (*Nov.*, 1951) *In French.*

Evidence on masses, spins and half-lives of $\mu^{\pm}$ and $\pi^{\pm}$ and π^0 as revealed by experiments with simple theoretical interpretation. 43 refs. up to Feb., 1951.

W. J. SWIATECKI

539.18

2134. Experimental search for the beta-decay of the π^+ meson. H. L. Friedman and J. Rainwater. *Phys. Rev.*, **84**, 684–90 (*Nov.* 15, 1951).

The possibility that nuclear β-decay is associated with the β-decay of the meson, formed during an intermediate step, has long been of interest in the development of meson theories. To explain nuclear β-decay, the β-decay rate for the π-meson should be comparable to its μ-decay rate. The present investigation is an attempt to detect other than $\pi-\mu$ events for π^+ mesons which stop in G-5 400 and 600 micron emulsions. The result is one or zero $\pi-e$ event compared to 1 419 $\pi-\mu$ events for mesons satisfying certain selection criteria. A collimating exposure chamber was used in the fringing magnetic field inside the vacuum chamber of the Columbia 164 in cyclotron to provide energy and direction selection of mesons at the photographic plate. The expected total energy spread for any point x along the plate was calculated to be about 1 MeV. Only mesons were considered which entered the top surface of the emulsion, ended in the emulsion and had directions and ranges within intervals including about 94% of the π-mesons. This procedure assured consideration of essentially all π-mesons but discriminated against μ-mesons produced by decays in flight.

A.

539.18

2135. Determination of the mean life-time of μ-mesons. J. Pernegr. Letter in *Nature* [*Lond.*] **168**, 1004 (*Dec.* 8, 1951).

From a comparison of the frequency of μ-mesons in C2 emulsions exposed at 1 780 m and 2 640 m, the latter under Pb absorbers, the mean life-time was found to be $2{\cdot}3 \pm 0{\cdot}3 \times 10^{-6}$ sec.

E. P. GEORGE

539.18

2136. The lifetime of the μ^+-meson. W. E. Bell and E. P. Hincks. Letter in *Phys. Rev.*, **84**, 1243 (*Dec.* 15, 1951).

Electronic circuits measure the delay between mesons stopping in a layer of Fe and decay electrons. The value $\tau = 2{\cdot}22 \pm 0{\cdot}02$ μsec is more accurate than, but in agreement with, previous measurements.

W. J. SWIATECKI

539.18

2137. Search for the production of V^0 particles by a 310-MeV bremsstrahlung beam. G. Cocconi and A. Silverman. Letter in *Phys. Rev.*, **84**, 1062 (*Dec.* 1, 1951).

Coincidences between protons and mesons from the assumed scheme $V^0 \rightarrow p + \pi^-$ never exceeded the expected background, affording additional evidence that the above scheme is not correct.

W. J. SWIATECKI

539.18

2138. The scattering of π-mesons by deuterons. S. Fernbach, T. A. Green and K. M. Watson. *Phys. Rev.*, **84**, 1084–9 (*Dec.* 15, 1951).

A study is made of the expected properties of the cross-section for scattering π-mesons by deuterons on the basis of the impulse approximation. The cross-section for high-energy mesons can then be expressed in a simple manner in terms of the cross-sections for meson scattering by free protons and neutrons. This provides a means of deducing the latter when the deuteron and proton cross-sections are known.

A.

539.18

2139. π^-–p scattering observed in a diffusion cloud chamber. R. P. Shutt, E. C. Fowler, D. H. Miller, A. M. Thorndike and W. B. Fowler. Letter in *Phys. Rev.*, **84**, 1247–8 (*Dec.* 15, 1951).

1 670 g cm^{-2} of 60 MeV π^- path length were observed in a single day's operation of a diffusion cloud chamber operated at 21 atm., and 3 (one doubtful) examples of π^-–p scattering were detected. The efficiency of scanning is considered to be high, and the resultant cross-section is ~ 3 millibarns.

J. G. WILSON

539.18

2140. "Anomalous" π–μ decay. H. Primakoff. Letter in *Phys. Rev.*, **84**, 1255 (*Dec.* 15, 1951).

The probability that the path length of a μ-meson emitted from a stationary π-meson may be < 450 microns (normal path length ~ 600 microns) due to simultaneous emission of photons is 1 in 5 000. It is not yet clear whether this is sufficient to explain all the anomalous π–μ decays observed so far.

R. H. DALITZ

539.18

2141. Meson masses and energetics of meson decay. W. H. Barkas. *Amer. J. Phys.*, **20**, 5–12 (*Jan.*, 1952).

A series of measurements of the π- and μ-meson masses and their decay energies is reviewed. Recent mass measurements made at the University of California Radiation Laboratory have employed an improved method in which the ratio of the π-meson mass to that of the proton and the ratio of the μ-meson mass to that of the π-meson were determined by measuring the ratios of ranges and ratios of momenta for particles of equal velocities. The absolute decay momentum of the μ-meson was also determined in the same series of experiments. Other experiments at the Radiation Laboratory in which quite different methods were used to obtain the π-meson mass and the decay energy of the μ-meson are also discussed. The measurements are consistent with a π-meson mass of 276 electron masses and a μ-meson mass of 210 electron masses. In addition, no contradiction is found for the assumptions that the π–μ decay is accompanied by a neutrino and the μ–e decay is accompanied by two neutrinos.

A.

539.185

2142. Coherent neutron-proton scattering by liquid mirror reflection. M. T. Burgy, G. R. Ringo and D. J. Hughes. *Phys. Rev.*, **84**, 1160–4 (*Dec.* 15, 1951).

A measurement of the coherent neutron-proton scattering amplitude, utilizing total reflection of slow neutrons from a liquid hydrocarbon, as first reported

in 1950. ($-3{\cdot}75 \pm 0{\cdot}03 \times 10^{-13}$ cm) was significantly different from existing values; the measurements have been continued with a series of liquids in order to investigate systematic errors and to improve the accuracy. Final measurements have now been made utilizing a series of carefully purified hydrocarbon liquids, and a method in which no measurement of neutron wavelength is necessary. The ratio of the amplitude of H to that of C has been determined to 0·3% and the final value of the H amplitude, including the error (0·5%) in the C amplitude is $(-3{\cdot}78 \pm 0{\cdot}02) \times 10^{-13}$ cm (standard error). A.

539.185 : 539.172 : 537.533

2143. The linear electron accelerator as a pulsed neutron source. B. T. FELD. *Nucleonics*, **9**, 51–7 (*Oct.*, 1951).

The advantages of the linear electron accelerator in time-of-flight neutron spectroscopy are outlined. The yield of photoneutrons from Cu, Ag and Ta targets bombarded with 20 MeV electrons are calculated. Thus a linear accelerator giving 120 (100 mA peak) pulses of 1 μsec duration per sec was found to give $1{\cdot}5 \times 10^{11}$ neutrons/sec with a Ag target. Yields obtained in experiments with a 16 MeV electron accelerator using Al, brass, Pb and U targets are given. L. R. SHEPHERD

539.185

2144. Boron carbide bricks for neutron absorption. C. SHEER AND J. TITTMAN. Note in *Rev. Sci. Instrum.*, **22**, 837–8 (*Nov.*, 1951).

A method of fabrication and some performance data. J. J. WILKINS

539.185

2145. Neutron refraction in O_2, N_2, He, A gases. A. W. MCREYNOLDS. *Phys. Rev.*, **84**, 967–72 (*Dec.* 1, 1951).

The index of neutron refraction has been studied by reflection of a neutron beam from a liquid/gas interface and observation of decreasing reflectivity with increasing gas pressure. Results verify that the index for gases is given by the same formulae which hold for liquids and solids. Comparative measurements of the different gases then give values for the coherent bound scattering cross-sections: assuming O = 4·2 barn as a standard, N = 11, He = 1·1, A = 0·5. A.

539.185

2146. Scattering of fast neutrons from O^{16}. E. BALDINGER, P. HUBER AND W. G. PROCTOR. Letter in *Phys. Rev.*, **84**, 1058–9 (*Dec.* 1, 1951).

The differential cross-section in the range 2–4 MeV was measured by recording the recoil nuclei. It can be accounted for by the following level scheme for O^{17}: $P_{\frac{1}{2}}$, $S_{\frac{1}{2}}$, $D_{\frac{3}{2}}$, $P_{\frac{3}{2}}$, $P_{\frac{1}{2}}$ at 1·9, 2·35, 3·33, 3·80, 4·40 MeV respectively. W. J. SWIATECKI

539.185 : 538.221

2147. Neutron scattering and polarization by ferromagnetic materials. C. G. SHULL, E. O. WOLLAN AND W. C. KOEHLER. *Phys. Rev.*, **84**, 912–21 (*Dec.* 1, 1951).

Neutron diffraction studies are reported on a series of magnetized and unmagnetized ferromagnetic materials. The diffraction patterns for unmagnetized, polycrystalline samples of Fe and Co are found to possess both nuclear and magnetic components with the latter in agreement with the magnetic scattering theory with respect both to intensity of scattering and form factor angular variation. Studies on the magnetic structure of Fe_3O_4 are shown to strongly support Néel's proposed ferrimagnetic structure. Predictions of the theory regarding intensity effects upon sample magnetization are fully confirmed and the Schwinger–Halpern–Johnson formulation of the interaction function between the neutron's magnetic moment and the internal fields in a ferromagnet is substantiated. A pronounced variation of intensity around the Debye ring in the diffraction pattern for a magnetized sample is found. Neutron polarization effects in the Bragg scattered beams from magnetized crystals of Fe and Fe_3O_4 have been studied, and it is shown that very highly polarized beams are obtained for certain reflections. This method of monochromatic beam polarization is found to compare very favourably with other methods with respect to polarization value, beam intensity and ease of obtainment. A.

STRUCTURE OF SOLIDS 539.2

539.2 : 666

2148. Density changes in fused silica. R. W. DOUGLAS AND J. O. ISARD. *J. Soc. Glass Techn.* **35**, T206–T225 (*Aug.*, 1951).

In continuation of previous work [Abstr. 3680–1 (1947)] on the configuration changes of glass in the transformation range, the density changes occurring in fused silica at 1 000°–1 500° have been studied. The equilibrium density curve has been determined and the time taken to reach equilibrium found for various temperatures. The coefficient of expansion at temperatures below 1 000° has been found to alter when the configuration changes; the density changes measured at room temperature are corrected for change of expansion in order to give the changes of density at the temperatures of heat treatment. The equilibrium density of fused silica is found to increase with increasing temperature, and this is attributed to the tendency of the open random network structure to break down at higher temperatures. The final section gives preliminary results on measurements of the volume of fused silica as a function of pressure in addition to time and temperature. A.

539.211

2149. The free energy of formation and the gap of solubility of alkali halide solid solutions. V. HOVI AND L. HYVÖNEN. *Ann. Acad. Sci. Fennicae, AI, No.* 106, 16 *pp.* (1951).

Expressions which are claimed to be closer approximations to the free energy and configurational free energy are derived from Wasastjerna's theory, numerical calculation, involving certain measurable factors of the component salts, providing critical solution temps of + 50°, − 50° and − 70°c for NaCl–NaBr, KCl–KBr and KCl–RbCl mixed crystals respectively. These values agree with available experimental data, and, for the first two cases, are

close to those provided by the thermodynamical method. A. J. KENNEDY

539.215.2 : 539.4.016

2150. The recrystallization texture of drawn aluminium wire. J. SAWKILL AND N. THORLEY. *Phil. Mag.*, **42**, 1369–72 (*Dec.*, 1951).

The recrystallization texture of high purity (99·995%) cold drawn Al wire has been found to be double, viz. [322], [100]. The [100] component is relatively weak. The scatter in the major [322] component increases, and the amount of the [100] component decreases, the higher the temperature of anneal. A.

539.215.4

2151. Relationship between the extinction coefficient and the particle size. H. E. ROSE. Letter in *Nature* [*Lond.*] **168**, 784–5 (*Nov.* 3, 1951).

This is important both from the theoretical aspect and also for the application of the photo-extinction method of particle size analysis. The present investigation has been undertaken because most of the previous data is unreliable and covers a range of diameters from about 1 to 80 microns. Up to 25 microns glass and polystyrene spheres were used, and beyond that size silica sand and desert sand. The author concludes that Brillouin's interpretation of the vector equation is correct. The experimental results are given as a curve. J. M. HOUGH

539.216.1

2152. Investigations on quartz filaments. E. EBERHARDT, H. KERN AND H. KLUMB. *Z. angew. Phys.*, **3**, 209–12 (*No.* 6, 1951) *In German.*

In the method described for preparing quartz filaments of predetermined const. average dia. (30–0·7μ), a Si rod (dia. 2–0·2 mm) is passed vertically into a const. pressure H_2–O_2 or coal gas–O_2 flame from a Ni burner, at a definite velocity. At the same time the rod is moved sideways, also at a definite but much smaller velocity. The softened portion of the rod is drawn out rapidly (5–25 m/sec) into a continuous filament, which is wound up on a highly-polished rotating drum. Data relating the velocities and dias. of the rod and filament and the composition of the gas mixture are given. The tensile strength of the filament increases with decreasing dia. (measured interferometrically), a max. value of 650 kg/mm^2 being reached for a dia. of 0·8μ. The torsion modulus is independent of the dia. for thicknesses up to 1·5μ, at $(4{\cdot}8 \pm 0{\cdot}7) \times 10^{11}$ dyne/cm.^{2} J. GRANT

539.216.1

2153. Correlation between initial Young's modulus and differential heat of sorption at zero regain for cellulosic fibres. D. K. ASHPOLE. Letter in *Nature* [*Lond.*] **169**, 37–8 (*Jan.* 5, 1952).

Statistical analysis, using an empirical linear relationship between the log of the heat of wetting and the moisture regain, shows that the differential heats of sorption of various dry cellulosic fibres correspond with heats of wetting which are intermediate among those of the cellulose fibres. Close correspondence exists between the recalculated differential heats of sorption at zero regain and the initial Young's modulus; values for 11 fibres are tabulated, and have a correlation coeff. of 0·928. It is deduced from these results that the H bonds give in the initial straining of such fibres, but that as a rule these bonds are largely responsible for the strength of the fibres right up to the breaking point. J. GRANT

539.217

2154. Remarkable increase by oil of the permeability of ordinary paper to water and to aqueous solutions. H. DEVAUX. *C.R. Acad. Sci.* [*Paris*] **233**, 1325–6 (*Nov.* 26, 1951) *In French.*

A comment on a paper by Kopaczewski [Abstr. 811 (1952)] pointing out that essentially the same phenomenon was described in 1912 [see Devaux, *J. Phys. Radium*, **2**, 891 (1912)]. Kopaczewski dealt with filter paper whereas Devaux used smooth glazed writing paper, but in both the effect is due to the greater affinity of water than of some oily substances for the paper fibres. J. IBALL

539.217

2155. The diffusion of copper in cuprous oxide. W. J. MOORE AND B. SELIKSON. *J. Chem. Phys.*, **19**, 1539–43 (*Dec.*, 1951).

Cuprous oxide strips were prepared by the oxidation of copper at 1 000°C. The diffusion of radiocopper in this material at 800 to 1 050° gave a self-diffusion coefficient, $D = 0{\cdot}0436 \exp(-36\,100/RT)$. Virtually the same D is obtained from experiments in which radiocopper is plated on copper strips, and the distribution of activity measured in the cuprous oxide film formed on oxidation in air. The observed D values are in accord with a predicted relation $k/D = 4$, where k is the parabolic rate constant for copper oxidation. It is suggested that parabolic rate constants with large negative entropies of activation and low heats of activation may be due to grain boundary diffusion. A.

539.232

2156. A simple procedure for the production of large-area transparent films of aluminium oxide with thickness between 50 and 300 mμ. K. STROHMAIER. *Z. Naturforsch.*, **6a**, 508–9 (*Sept.*, 1951) *In German.*

The films described can replace collodion for many uses. The film is formed anodically from aluminium foil. The technique is described in detail. Windows of size 4×5 sq. cm can be made with little difficulty. The films are amorphous and optically uniform. S. TOLANSKY

539.26

2157. The stretching and relaxing of polyethylene. R. A. HORSLEY AND H. A. NANCARROW. *Brit. J. Appl. Phys.*, **2**, 345–51 (*Dec.*, 1951).

By using an X-ray beam of very small cross-sectional area, a series of X-ray diffraction patterns has been obtained over the region of the neck that is produced when randomly oriented polythene is stretched. These indicate that the orientation over the region of the neck produced by stretching at room and lower temperatures is abnormal in that it does not consist of a gradual alignment of the polymer chains with the direction of stretch, but that at intermediate stretches the preferred orientation is such that the (011) axis is parallel to the stretch direction. At higher stretches, however, there is a gradual tilting of the crystallites until they are finally aligned with their chain axis parallel to the direction of

stretch. At temperatures in the region of 100°C this intermediate step does not take place and the crystallites gradually align themselves with their chain direction parallel to the axis of the monofilament. The relaxing of a polythene neck at 110°C has also been shown to be non-random. The direction of preferred orientation changes as relaxation proceeds from that in which the *a* axis of the crystallites is perpendicular to the axis of the monofilament, to that in which the *a* axis is parallel to this direction. A tentative explanation has been put forward to explain this behaviour. A.

539.26 : 669

2158. The xi-phase and a new sigma phase. D. SUMMERS-SMITH. Letter in *Nature* [*Lond.*] **168,** 786 (*Nov.* 3, 1951).

Co_2Mo_3, existing between 1 250°C and 1 620°C, has a σ-phase structure with interplanar spacings similar to, but slightly smaller than, those of FeMo. The occurrence of the σ- and ξ-phases in the binary systems of Fe and Co with Cr, Mo and W are compared. A. E. DE BARR

539.27

2159. The electronographic investigation of natural cellulose ramie. A. L. ZAÏDES AND I. G. SINITSKAYA. *Dokl. Akad. Nauk SSSR,* **80,** 213–14 (*No.* 2, 1951) *In Russian.*

Using 80–100 kV electrons, diffraction photographs were taken of fine fibres of natural cellulose ramie; [photograph reproduced]. After exposure to the electron beam for 1 min some of the sharply oriented diffraction maxima disappeared, being replaced by diffuse rings. The electronogram agreed exactly with an X-ray photograph of the same material both in the positions and widths of the maxima and gave some additional information. Reflections were observed with the following *d* values:—equatorial, 6·18, 5·72, 4·23; at 45°, 4·46; meridional, 3·42, 2·68, 2·05, 1·28, 1·14 Å. The latter class give a period of 10·26 Å along the fibre axis. A. L. MACKAY

539.27

2160. Changes of MoO_3 crystals in the electron microscope. H. KÖNIG. *Z. Phys.,* **130,** 483–92 (*No.* 4, 1951) *In German.*

In an electron microscope, crystals of MoO_3 are subjected to bombardment with 100 kV electrons. The changes in the form of the crystals are examined and electron diffraction by the same crystals is used to investigate changes in crystal structure and in chemical composition. The latter method shows that the change from MoO_3 to MoO_2 can take place. As in the case of organic compounds [see Abstr. 7308 (1951)] evidence is provided to show that the changes are not always the same as those produced by heating. J. IBALL

539.27

2161. Electron microscope and diffraction studies of metallic smoke. R. TAKAGI. *J. Mech. Lab., Tokyo,* **5,** 107–10 (*July,* 1951).

R. D. Heidenreich observed many fringes called "extinction contours" in the electron microscope images of Al thin sections prepared by an electrolytic method, and explained them by the variation of thickness and distortion of crystals. Many characteristic fringes similar to them were observed in the electron microscope images of thin plate crystals of MoO_3 probably of uniform thickness. These fringes seem to have been caused solely by the distortion of crystals. A.

539.27

2162. An electron diffraction study of organic films. I–II. S. NAGATA. *Techn. Rep. Osaka Univ.,* **1,** 167–77 (*Oct.* 2, 1951).

The molecular orientations of thin films of acids, alcohols, hydrocarbons, especially aromatic compounds on the steel surface, were investigated by the electron diffraction method and their coefficients of friction at the boundary condition were measured. A close relationship is observed between molecular structure, orientation and frictional behaviour. The effect of tricresyl phosphate and dibutyl phthalate as additive agent upon above compounds was also investigated. In general, both orientation and frictional behaviour change with the quantity of these additives, and the optimum quantity may be about 1·5 mol. %. A.

539.27

2163. [An electron diffraction study of] the reduction of silver bromide to silver. J.-J. TRILLAT. *C.R. Acad. Sci.* [*Paris*] **233,** 1188–9 (*Nov.* 12, 1951) *In French.*

A completion of earlier work [*J. Phys. Radium,* **7,** 89–92 (*No.* 2); 497–502 (*No.* 12, 1936)]. The behaviour of thin films of AgBr exposed to light and to electron bombardment was examined, and the deposition of Ag demonstrated by the appearance of Ag diffraction rings. The Ag is in the form of very small crystals, which are oriented at random even when the initial AgBr film is a single crystal. The rate of deposition varies widely from point to point, and depends on the mode of preparation of the film. Various physical effects induced by electron bombardment were observed. R. S. PEASE

539.27 : 539.217.1

2164. Electron microscopic replica studies of porosity in fused iron catalysts. J. T. MCCARTNEY AND R. B. ANDERSON. *J. Appl. Phys.,* **22,** 1441–3 (*Dec.,* 1951).

The preparation of various replicas of a fused Fe catalyst is described. Micrographs of these replicas show comparable fine structures that are attributed to the pores developed in the catalyst upon reduction. Dimensions of these fine structures compare reasonably well with pore diameters calculated from pore volume-surface area determinations. A.

ELASTICITY . STRENGTH . RHEOLOGY 539.3/.8

539.31 : 536.7 : 541.64

2165. Statistical thermodynamics of rubber elasticity. F. T. WALL AND P. J. FLORY. *J. Chem. Phys.,* **19,** 1435–9 (*Dec.,* 1951).

Two principal differences between the theories of rubber elasticity advanced by James and Guth and by other authors are examined in the light of certain fundamental concepts. First the distribution functions for molecular chain lengths in vulcanized rubber networks are considered from the point of view of

symmetry. Assuming a relaxed network to be isotropic and a network subject to uniform stress in one direction to be transversely isotropic, it is possible to formulate very general mathematical forms with respect to which the actual distribution functions must be compatible. It is shown that the functions employed by Wall and by Flory and Rehner are consistent with the required general forms; those of James and Guth are incompatible with any degree of isotropy and suggest an aeolotropic structure for vulcanized rubber. It is also shown that the configurational entropy of vulcanization must be zero and quite independent of the statistical nature of the chains comprising the network, providing the network is not deformed macroscopically. The negative entropy of vulcanization derived by James and Guth arises from their erroneous identification of the configurational probability with the number of configurations which a microscopically specified network structure could assume, rather than with the total number of configurations for all network structures which are consistent with the requirements of the vulcanization process. The assertion of James and Guth that the configurations of the polymer chains are altered in some systematic manner by the introduction of cross-linkages and their concept of "internal pressure" originate in this error. The present article attempts to clarify the currently prevalent confusion with respect to rubber elasticity theory. A.

539.32

2166. A calculation of the elastic shear constants of β-brass. H. Jones. *Phil. Mag.*, **43**, 105–12 (*Jan.*, 1952).

The stability of β-brass, with respect to shears across the (110) plane in the direction [1$\bar{1}$0], is considered and is shown to be due, mainly, to the change of the Fermi energy as a result of the shearing of the Brillouin zone. Calculations are made which show that this effect contributes approximately 10^{11} dynes/cm^2 to the shear constant $\frac{1}{2}(c_{11} - c_{12})$, and a rather larger amount to c_{44}. The constitution of the elastic shear constants, as the sum of three terms, is examined and a satisfactory account of the observed values is obtained. The difficulty experienced in attempting to retain the β-phases by quenching is briefly discussed. A.

539.32 : 537.228.1

2167. A piezoelectric method for determining Young's modulus and its temperature dependence. H. E. Stauss, F. E. Martin and D. S. Billington. *J. Acoust. Soc. Amer.*, **23**, 695–7 (*Nov.*, 1951).

A resonance method for determining Young's modulus in metals, based on support of the specimen at its central node for longitudinal vibrations, with the supporting rod articulating at its lower end with a piezo-electric crystal, has been developed. Utility of the method was extended by adapting it to measurement of changes in Young's modulus with temperature. A.

539.32

2168. The adiabatic elastic constants of rock salt. W. C. Overton, Jr and R. T. Swim. *Phys. Rev.*, **84**, 758–62 (*Nov.* 15, 1951).

The velocities of propagation of 10 Mc/s longitudinal and transverse sound waves in single crystals of rock salt have been measured over the temperature range from 60°K to 300°K by means of the ultrasonic pulse method. From these velocities the adiabatic elastic constants have been calculated, with the results that $c_{11} = 4{\cdot}828 \pm 0{\cdot}015$, $c_{44} = 1{\cdot}273 \pm 0{\cdot}005$, and $c_{12} = 1{\cdot}276 \pm 0{\cdot}025$ at 300°K in units of dyne/cm$^2 \times 10^{11}$. The values of these elastic constants extrapolated to absolute zero temperature are, in these units, 5·750, 1·327, and 0·986, respectively. The adiabatic compressibility has been calculated from c_{11} and c_{12} and is $4{\cdot}07 \times 10^{-12}$ cm^2/dyne at 300°K. The Debye characteristic temperature is computed to be $292{\cdot}6 \pm 0{\cdot}5$°K at $T = 0$°K. A.

539.32 : 541.64

2169. A vibrating cantilever method for the investigation of the dynamic elasticity of high polymers. K. W. Hillier. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 998–1005 (*Nov.*, 1951).

A method is described for obtaining dynamic values of Young's modulus at low frequencies (20 to 100 c/s) by using the forced resonance of a vibrating cantilever. Provision has been made for keeping the apparatus at a constant temperature and a few measurements of the dynamic modulus are given for polythene at 30° and 40°c. The theory of the vibrations of a cantilever including viscous internal damping is discussed. The results continue previous work [Abstr. 1262 (1950)] carried out at higher frequencies by a different method and indicate the continuity of the dynamic modulus-frequency relation between 20 kc/s and 20 c/s for polythene. "Static" measurements have also been carried out and agree with those published earlier. Even at the lowest frequency the dynamic modulus is still three times the "static" value, and it is concluded that lower frequencies should be investigated. A.

539.373 : 548.0

2170. The crystallographic aspect of slip in body-centered cubic single crystals. II. Interpretation of experiments. A. J. Opinsky and R. Smoluchowski. *J. Appl. Phys.*, **22**, 1488–92 (*Dec.*, 1951).

A new method for determining the ratios of the critical shear stresses has been applied to data taken from the literature and to original results. Measurements of yield strength were found to be not too satisfactory for the investigation of the slip behaviour of the body-centred cubic materials. On the other hand, any method which determined the slip plane and the orientation of the tensile axis gave useful results. In all instances where the data were available, the ratio of the critical shear stresses on {123} and {112} was very close to unity, and did not change with temperature. The ratio of the critical shear stresses on {123} and {110} changes with temperature and composition, with the value of S_{123} generally being higher than that for S_{110}. A.

539.373 : 548.0

2171. The mechanical behaviour of single crystals of certain face-centred cubic metals. E. N. da C. Andrade and C. Henderson. *Philos. Trans. A*, **244**, 177–203 (*No.* 880, 1951).

Single crystal rods of Au, Ag and Ni have been prepared from the melt by a modified cooling method.

The three metals differ in that the Au is very pure and has no surface contamination; the Ag is very pure and the surface normally shows contamination; the Ni is markedly less pure. These three features find expression in the results. The stress-glide relationship has been investigated over the whole range to fracture, special attention being paid to the region of small glide. At very small glides the results show certain variations attributed to metastable conditions. For pure metals at low temperatures a region of easy glide has been established, which is absent in Ni. Considerations of the variation of hardening with temperature at constant glide show that, at moderate glide, rise of temperature at low temperature promotes hardening, but rise of temperature at high temperature leads to decrease of hardening. From these results it is concluded that, in metals without notable impurity, glide is due to two distinct processes, first the initiation of glide planes, which temperature agitation tends to check, and secondly to glide proceeding on planes already initiated, which temperature agitation tends to promote. The surface contamination of Ag single crystals which takes place by exposure to air at room temperature raises the critical shear stress somewhat, but has a much more marked effect on the hardening after some tens of per cent of glide has taken place, which is attributed to diffusion of the impurity atoms, probably O, taking place during the travel of the dislocations. This is distinct from normal diffusion, which is negligible at room temperature. The results on the effect of surface contamination explain abnormalities previously noted with Ag. The close connection of asterism and hardening is exhibited in the results obtained with Au and Ag. In particular, Ag in the region of easy glide shows very small asterism, even at large glide. The cube root of the breaking stress of all metals in single-crystal form has been found to show a linear relationship with temperature.

A.

539.374

2172. Diagrams for regimes of mechanical states. S. I. GUBKIN. *Izv. Akad. Nauk SSSR, Otdel. Tekh. Nauk, No.* 8, 1165–82 (1950) *In Russian.*

The author's summary is "Two types of graphical representation of mechanical states are proposed which permit a classification of mechanical states, the mechanism of plastic deformation, and of the principal methods of metal shaping by pressure. A proposal is made to separate the mechanisms of plastic deformation into 2 classes; mechanisms with diffusion; mechanisms free of diffusion. Certain properties are pointed out for each class."

MATHEMATICAL REVIEWS

539.374

2173. Approximation methods in the theory of viscoelastic behaviour. II. F. SCHWARZL. *Physica,* **17**, 923–9 (*Oct.*, 1951) *In German.*

For Pt I, see Abstr. 1246 (1952). The approximation system of viscoelastic theory is completed by an approximation equation for the calculation of spectra from the imaginary components of the complex compliance and modulus (damping): The spectra multiplied by t are obtained by differentiation of $E_2(\omega)/\omega$ with respect to t. Finally the entire approximation system is checked on the Maxwell and Kelvin element. The most important results are: The creep curve without flow is parallel to the real part of the compliance and runs somewhat above the latter. The relaxation curve is parallel to the real part of the modulus and runs somewhat below the latter.

A.

539.374

2174. Inhomogeneities in the plastic deformation of metal crystals. R. W. K. HONEYCOMBE. *J. Inst. Met.*, **80**, 45–56 (*Oct.*, 1951).

I. Occurrence of X-ray asterisms (45–9).

A study has been made of the occurrence of X-ray asterisms from deformed single crystals of a typical hexagonal metal (Cd) and a typical cubic metal (Al). Cd can be extended by more than 100% elongation in tension without the appearance of asterisms in X-ray Laue photographs; asterisms occur only when the crystals are macroscopically bent or kinked. On the other hand, they are present in photographs from Al crystals after less than 4% elongation in tension. These asterisms contain intensity maxima which are shown to be a direct consequence of the deformation and not of a secondary phenomenon such as polygonization. On annealing, extended Cd crystals give sharp Laue spots, and the bent crystals polygonize very uniformly at 300°C. The appearance of asterisms from lightly extended Al crystals is unaltered by annealing at 250°C, at which temperature partial recovery of the yield stress occurs; but when the temperature is raised to 475°C the asterisms become further fragmented as a result of polygonization. These experiments suggest that tensile deformation causes Al, but not Cd, crystals to break down into a series of slightly disoriented blocks connected by regions of distortion or lattice curvature.

A.

II. X-ray and optical micrography of aluminium (49–56).

A technique of X-ray microscopy is used in conjunction with optical micrography to investigate the structure of large Al crystals deformed by small amounts in tension. Two types of microscopic inhomogeneity which cause local variations in orientation are described. First, there are narrow regions of curvature or kink bands separating slightly disoriented lamellae of the crystal; these bands occur initially on (110) planes, the normal to which coincides with the active slip direction. The second type of inhomogeneity comprises bands of secondary slip, which are regions nearly devoid of primary slip traces, in which slip on another system occurs preferentially. These bands are almost parallel to the primary slip planes in the early stages of deformation. The effects of crystal orientation, temperature and speed of deformation and purity of metal on the occurrence of kink bands are investigated, and it is found that these are usually present after deformation, except when this occurs from the beginning by conjugate slip. Bands of secondary slip also generally occur, and in crystals deforming by conjugate slip, they are often of macroscopic size. The inhomogeneities play an important role in the deformation of Al and account for many of the differences between

this metal and Cd, as the occurrence of X-ray asterisms, the marked differences in strain-hardening, and the extent to which recovery can occur on annealing. A.

539.374

2175. A problem in dynamic plasticity: the enlargement of a circular hole in a flat sheet. W. FREIBERGER. *Proc. Camb. Phil. Soc.*, **48**, 135–48 (*Pt I*, 1952).

The problem discussed in this paper is the enlargement of a circular hole in a flat sheet of which the material is in plastic flow under constant shear stress; inertia terms are taken into account in the equilibrium equations so as to permit the occurrence of high velocities. The treatment is in some ways analogous to that of problems in one-dimensional compressible gas flow. The characteristic equations are seen to represent straight lines under certain initial conditions; this facilitates consideration of any mode of enlargement; in particular, uniform acceleration is illustrated by numerical calculations. There appears a circular shock-front, i.e. a discontinuity in thickness and velocity moving ahead of the hole. The initial conditions for the existence of this "simple wave" solution involve a singularity at the centre of the plate. In general, the characteristic curves will not be straight lines and the equations are best solved step by step. Their characteristic form is well adapted to such a process; this is outlined for the interesting case of initial enlargement with uniform velocity followed by expansion under constant acceleration. A.

539.374 : 553.611.1

2176. A contribution to the methods of measuring the plasticity of clays. R. AHLBERG. *Trans Chalmers Univ. Techn.* [*Gothenburg*] *No.* 119, 22 *pp.* (1951).

A method has been elaborated for the determination of the plasticity of ceramic clays, using Hoeppler's consistenciometer. Two English clays, and clays with pure cation complexes made from them, have been investigated. The plasticity numbers obtained by this method do not correspond to the Atterberg–Rieke numbers, but there is reason to suppose that the former are more correct. A.

539.38

2177. On the nature of the initial deformation. G. MÜLLER AND W. ENGELHARDT. *Ann. Phys.* [*Lpz.*] **9**, 357–62 (*No.* 6–7, 1951) *In German.*

Small extensions of a spiral copper spring are used to obtain strain-time curves at various temperatures. Kuhlmann and Masing's equation [*Z. Metallkde.* **39**, 361 (1948)] is used to represent the results.

J. E. CAFFYN

539.4.016

2178. The prediction of uranium deformation textures. E. A. CALNAN AND C. J. B. CLEWS. *Phil. Mag.*, **43**, 93–104 (*Jan.*, 1952).

Tension, compression and rolling textures have been derived for the orthorhombic metal α-uranium. From a consideration of the relative importance of the slip and twinning mechanisms it is possible to differentiate between the textures developed after slight and severe deformations at both room and elevated temperatures. A.

539.4.016 : 548.73

2179. Quantitative measurement of preferred orientation in rolled uranium bars. G. B. HARRIS. *Phil. Mag.*, **43**, 113–23 (*Jan.*, 1952).

The preferred orientation of U bars hot-rolled and cold-rolled in the α-range has been determined quantitatively by X-ray diffraction using a Geiger counter. It is shown that hot rolling with a slight reduction causes the 010 planes to become strongly and the 110 planes weakly oriented perpendicular to the rolling direction. Further hot rolling causes the 110 planes to become strongly and the 010 planes weakly oriented perpendicular to the rolling direction. Cold rolling with light reduction causes the 010 planes to become strongly and the 130 planes weakly oriented in the planes perpendicular to the rolling direction. A.

539.4.016.2

2180. Low-angle scattering of X-rays by cold-worked metals. J. BLIN AND A. GUINIER. *C.R. Acad. Sci.* [*Paris*] **233**, 1288–90 (*Nov.* 19, 1951) *In French.*

Geiger counter measurements of low-angle scattering by cold-worked and recrystallized Cu and Ni suggest that the effect of cold-working is to produce sub-microscopic cavities in the metal. Approximately 10^{19} cavities per cm^3, of radius of gyration about 7 Å, are indicated and they disappear on recrystallization.

A. E. DE BARR

539.4.016.2 : 548.732

Diffraction pattern of cold worked metals. *See Abstr.* 2252–3

539.43

2181. Some aspects of the relation between the relaxation spectrum and the creep spectrum. A new mathematical relation concerning the delta function. B. GROSS AND H. PELZER. *Rep. Brit. Elect. Res. Ass., Ref. L/T*264, 15 *pp.* (1951).

Shows how the electric network analogue provides an illustration of the relation between the relaxation spectrum and the creep spectrum of a visco-elastic material. This illustration leads incidentally to a mathematical relation which appears to be novel. A.

539.434

2182. Formula for creep curves of metals. E. N. DA C. ANDRADE. Letter in *Nature* [*Lond.*] **168**, 1007 (*Dec.* 8, 1951).

A reply to Abstr. 1255 (1952), showing that if the 3 correct constants are used in the Andrade equation for polycrystalline metals, as deduced by Kennedy's method [Abstr. 1200 (1949)], the calculated results are somewhat better than those provided by the Hasiguti 4-constant formula, the constants of which appear to have no physical significance. The single crystal results can also be fitted more simply.

A. J. KENNEDY

539.501

2183. An investigation into the rheological properties of bitumen. I. Maxwell-body and elastic dispersions. M. REINER. *Bull. Res. Coun. Israel*, **1**, 5–25 (*Aug.*, 1951).

It is shown that while for infinitesimal elastic strain e, no difference in the rheological behaviour of sols and gels can be distinguished, the first represented

by a structural formula of the type: $S = N - K = N - (H/N)$, the second by $G = N/M = N(H - N)$; this is not so when the strain is finite. In the latter case, the true viscous resistance of a prism of length l in extension is measured by $f = \dot{l}/l$, while the "viscosity" due to Maxwellian relaxation of the stresses is measured by $\dot{e}$ which is equal to f only when the strain is measured in accordance with Hencky. The measure of the strain e, when finite, not being unequivocal; different flow curves will result from different measures of strain, even in pure extension. In simple shear, an elastic sol will exhibit flow curves similar to those in pure deformation, while an elastic gel will simulate variable viscosity. Rheological observations of large deformations of materials which may exist in the sol and gel state, such as bitumen, therefore supply information from which an insight into the structure of the material can be gained. A.

539.67

2184. A note on the measurement of damping in vibrating rods. G. G. PARFITT. *Brit. J. Appl. Phys.*, **2**, 327–9 (*Nov.*, 1951).

The theory of the determination of dynamic elastic modulus and damping from observations of the resonance curves of thin rods vibrating longitudinally or in torsion is discussed. Formulae are derived for these quantities in terms of resonance frequency and bandwidth for cases where the higher-order harmonics are used and where the damping is neither very small nor independent of frequency. A formula given by Lethersich and Pelzer [Abstr. 3449 (1950)] is amended. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.11 : 539.13

2185. Determination of dissociation energies of diatomic molecules from spectroscopic intensity measurements. L. HULDT AND A. LAGERQVIST. *Ark. Fys.*, **3**, 525–31 (*Paper* 32, 1951).

The chemical equilibrium can be calculated from spectroscopic line intensity measurements and temperature measurements of an acetylene-air flame fed with a metallic salt solution. The dissociation energy of the metal oxide can then be determined from it. The dissociation energies of CrO and MnO were obtained in this way. The result is $D_{CrO} = 4{\cdot}4 \pm 0{\cdot}5$ eV, $D_{MnO} = 4{\cdot}0 \pm 0{\cdot}4$ eV. A.

541.123.2

2186. Binary liquid mixtures. I. Heat of mixture of the system ethyl alcohol–chlorbenzol–brombenzol–toluol. W. SCHULZE. *Z. phys. Chem.*, **197**, 105–15 (*No.* 1–2, 1951) *In German.*

541.123.2

2187. Binary liquid mixtures. II. Thermodynamic examination of partial pressure data. W. SCHULZE. *Z. phys. Chem.*, **198**, 314–17 (*No.* 5–6, 1951) *In German.*

Describes a simple method for ascertaining whether a given series of partial pressure measurements satisfies the Duhem–Margules equation. The curve of the total pressure of binary mixtures can be represented in the limiting ranges by the linear relationship between $x_1x_2/\Delta \log P$ and the mole fraction. F. LACHMAN

541.123.5

2188. Utilization of radiocalcium for the study of the exchange of calcium ions in the system $CaSO_4$–$CaCl_2$. J. GOVAERTS. *Ann. Soc. Sci. Brux.*, **65** (*Sér.* 1) 129–34 (1951) *In French.*

Exchange of Ca ions is studied, by use of radio-Ca of period 180 days, in an aqueous phase of $CaCl_2$ containing a solid phase of $CaSO_4$. Periods of contact were varied from 30 minutes to 6 days, and the results indicated a feeble exchange from the outset, which, however, only proceeded slowly. The mechanism of the exchange is discussed. H. H. HODGSON

541.123.5 : 539.155.2

2189. Separation of the stable isotope of sulfur 34. E. D. NORTH AND R. R. WHITE. *Industr. Engng Chem.*, **43**, 2390–7 (*Oct.*, 1951).

The exchange reaction $S^{34}O_2$ (gas) + $HS^{32}O_3$ (aq.) $\rightleftharpoons$ $S^{32}O_2$ (gas) + $HS^{34}O_3$ (aq.) has been studied. A 2 in column 63 ft high was used. Separation factors between 1·1025 and 1·0155 were obtained; increasing temperature up to 50°c was shown to be beneficial.

541.124

2190. The thermal decomposition of barium azide. J. G. N. THOMAS AND F. C. TOMPKINS. *Proc. Roy. Soc. A*, **210**, 111–24 (*Dec.* 7, 1951).

See Abstr. 1278 (1952). The thermal decomposition of unirradiated azide and the effect of short-period preirradiation on this process has been studied. Nucleus formation is considered to be the production of *F*-centres which, by interaction with vacant anion sites, acquire mobility and so aggregate to form more stable *F*-centres, or nuclei. Nuclear growth involves decomposition at the metal-salt interface, and the nitrogen produced diffuses out through the crystal. The activation energy for growth of small nuclei is shown to be higher than that for growth of nuclei of visible size; this concept requires the introduction of a slow growth correction, and the pressure of nitrogen expressed as a function of time of heating t is then given by a relation of the formula $p = \text{const.}\,(t - y)^6$. The effects of preirradiation in promoting nucleus formation and the processes occurring in the ageing of freshly prepared azide are also discussed. A.

541.124

2191. Demonstration of bimolecular anionotropic change. B. D. ENGLAND AND E. D. HUGHES. Letter in *Nature* [*Lond.*] **168**, 1002–3 (*Dec.* 8, 1951).

Presents kinetic data for the bimolecular reactions of both 1-methylallyl bromide and crotyl bromide

with LiBr in acetone, claimed to be the only indubitable demonstration of the S_N2' mechanism of bimolecular isomeric rearrangement and substitution in anionotropic systems. F. LACHMAN

541.124 : 548.7

2192. On the reaction of silver bromide crystals containing sulphur, with bromine and silver. L. JUNG, O. STASIW AND J. TELTOW. *Z. phys. Chem.*, **198**, 186–99 (*No.* 1–4, 1951) *In German.*

The reaction of AgBr containing S (brown-coloured), with Ag and Br was investigated experimentally as a function of temperature, time and concentrations. Experiments were also carried out on AgBr with additions of $CdBr_2$ and the results found to be in quantitative agreement with the Schottky–Wagner "disorder" theory. The reaction isotherm for the AgBr system is calculated theoretically.

C. A. HOGARTH

541.124 : 548.733

***In situ* X-ray diffraction studies of heterogeneous reactions.** *See Abstr.* 2256

541.127

2193. Density measurements in gaseous detonation waves. G. B. KISTIAKOWSKY. Letter in *J. Chem. Phys.*, **19**, 1611–12 (*Dec.*, 1951).

The time-variation of density as a gaseous detonation wave passes through a particular section of the containing tube has been measured by recording the variation in absorption of a soft X-ray beam, 2–4 mm thick, traversing the tube. The transmitted X-ray intensity was measured by means of a terphenyl scintillation counter. Experiments on mixtures of (*a*) oxygen, acetylene and methyl bromide, and (*b*) oxygen and methyl bromide did not reveal the high density region theoretically expected to occupy much of the reaction zone; it is concluded that for these gas mixtures the reaction zone thickness is probably < 1 mm, which is too small to be resolved by the X-ray beam used. A. SCHOFIELD

ELECTROCHEMISTRY 541.13

541.133

2194. Transference numbers for KCl crystals. F. KERKHOFF. *Z. Phys.*, **130**, 449–56 (*No.* 4, 1951) *In German.*

It has been found that not only the value of electrolytic conductivity but also the transference numbers of KCl crystals depend largely upon the presence of divalent cations (Ba^{++} in this case). F. LACHMAN

541.135

2195. Concentration polarization in electrolytes after previous chemical reaction, and its part in the stationary polarization resistance at equilibrium potential. H. GERISCHER AND K. J. VETTER. *Z. Phys. Chem.*, **197**, 92–104 (*No.* 1–2, 1951) *In German.*

By assumption of an adhering diffusion boundary layer, and the application of the second Fich law, together with a rate addition for a homogeneous reaction in the electrolyte, the total concentration distribution concentration in the layer is approximately derived in dependence on the c.d. for small changes of concentration; thence the polarization resistance is calculated at the equilibrium potential. Various cases are discussed, and for the important one in which the concentration of the potential determining substance is small with respect to that of other materials, the entire course of the polarization concentration and of the limiting reaction current are evaluated. H. H. HODGSON

541.135 : 534.39

2196. The effect of ultrasonic radiation on the electrolytic separation of deuterium. D. F. MASON, R. E. BIDDICK AND C. A. BOYD. *J. Chem. Phys.*, **19**, 1551–4 (*Dec.*, 1951).

The application of ultrasonic radiation to the polished platinum cathode of an electrolysis cell increases the coefficient for the electrolytic separation of deuterium. The radiation also decreases the temperature dependence of the separation coefficient. This is thought to be due to the rapid removal of the discharged gases by the ultrasonic radiation. This prevents the surface-catalyzed exchange reaction between the discharged gases and the electrolyte. A.

541.135 : 539.155.2

Isotope enrichment by electrolytic transfer. *See Abstr.* 2045–7

541.135.5

2197. Alternating current polarization of electrodes with a potential-defined step at the equilibrium potential. I. H. GERISCHER. *Z. phys. Chem.*, **198**, 286–313 (*No.* 5–6, 1951) *In German.*

The connection between the a.c. apparent resistance at an electrode in an a.c. circuit and the kinetic processes at the phase boundaries is investigated, and conclusions are derived therefrom concerning these processes. The electrode is regarded as a condenser (with double layer capacity) to which a kinetic polarization resistance lies parallel. In this paper the cases of pure diffusion and of diffusion following homogeneous reaction are considered. It is found that the kinetic polarization resistance is strongly dependent on the frequency, and that this dependence enables the potential mechanism to be determined. 9 diagrams. H. H. HODGSON

541.135.5

2198. The redoxokinetic effect—a general phenomenon. K. S. G. DOSS AND H. P. AGARWAL. *Proc. Indian Acad. Sci. A*, **34**, 229–35 (*Oct.*, 1951).

When an alternating field is incident on two Pt electrodes, dipped in an aqueous solution containing quinhydrone, a d.c. potential is developed at each of the electrodes; it has been named the "redoxokinetic potential," and the phenomenon—the "redoxokinetic effect." Data from the following redox systems: Fe^{++}–Fe^{+++}, I^-–I_2, $K_2Cr_2O_7$–$Cr_2(SO_4)_3$ and Sn^{++}–Sn^{++++}, indicate the redoxokinetic effect to be a general phenomenon. The effect of redox ratio on the redoxokinetic potential is discussed. There are 6 tables of data. H. H. HODGSON

541.135.5

2199. Theory of redoxokinetic effect and a general method for the determination of "α" of absolute reaction rates. K. S. G. DOSS AND H. P. AGARWAL. *Proc. Indian Acad. Sci. A*, **34**, 263–71 (*Oct.*, 1951).

It is found from theoretical considerations for small

.c. fields that the redoxokinetic potential is proportional to the square of the a.c. field, and this is confirmed by experimental data from the Fe^{++}–Fe^{+++} system. From observed values of the redoxokinetic potential, a general method has been obtained for the *d–l* termination of "α"—a factor introduced in the theory of absolute reaction rates as applied to electrode processes. "α" is 0·4987 ± 0·0001 for the Fe^{++}–Fe^{+++} system (both 0·005M) containing 1·0M H_2SO_4 as the supporting electrolyte; when both are 0·25M without any supporting electrolyte, "α" is 0·39, and the significance of this low value needs further investigation. H. H. HODGSON

541.135.5

2200. A comparative study of unpolarizable and polarizable metal-solution systems. D. MACGILLAVRY. *J. Chem. Phys.*, **19**, 1499–1504 (*Dec.*, 1951).

The properties of the metal-solution potentials of Ni in Ni-free hydroxide and phosphate solutions are compared with the properties of unpolarizable electrodes and with the properties of polarizable metal-solution systems. The electrochemical equilibria of unpolarizable systems are analysed in terms of transfer mechanisms between the phases present. In the absence of any electrochemical equilibria, the metal-solution potentials are interpreted as *adsorption potentials*. Chemisorption in the inner Helmholtz layer is discussed in connection with "reversibility" and polarizability of the system. A.

541.136

2201. Temperature effect of the half-element Zn/Zn^{++}. M. BONNEMAY. *J. Rech. Cent. Nat. Rech. Sci., No.* 16, 9–12 (1951) *In French.*

The various components are analysed of the e.m.f. of the cell:

$$\begin{matrix} Zn/ZnSO_4/ZnSO_4 & /Zn \\ T \quad T & T+dT \;\; T+dT \end{matrix}$$

and the method indicated for measurement of the temperature coefficient of the Zn electrode at constant activity. Experimental data with curve are given, but reproducibility is rendered difficult perhaps by oxidation of the Zn and of the amalgams utilized. The variation of entropy from the reaction $Zn \rightleftharpoons Zn^{++} + 2\theta$ is $\Delta S = -47$ k cal per degree, the $-$ sign indicating increase of entropy with ionization of Zn. H. H. HODGSON

541.138

2202. A theory of irreversible polarographic waves. P. DELAHAY AND J. E. STRASSNER. *J. Amer. Chem. Soc.*, **73**, 5219–22 (*Nov.*, 1951).

An equation for irreversible polarographic waves is derived by assuming that the current at any point of the wave is controlled by the rate of the electrode process and by the rate of diffusion of the substance reacting at the electrode. The dependence of the rate constant for the electrode process on the potential of the dropping mercury electrode is interpreted on the basis of the theory of absolute rates. The free energy of activation and the transfer coefficient for a given electrode reaction are computed from the corresponding current-voltage curve. The theory is applied to the reduction of iodate ion, and some experimental factors that might possibly affect the rate of electrode processes are examined. Relatively large variations of the rate of the electrode process are caused by the addition of gelatin. The number of electrons involved in the rate-determining step of the reduction of iodate ion is calculated for solutions of various *p*H. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14 : 541.127

2203. The kinetics of the photolysis of acetaldehyde. II. The rate of production of methyl radicals. A. S. BUCHANAN. *J. Chem. Soc.* (1951) 2317–20 (*June*).

For Pt I, see Abstr. 8302 (1951). The rate of production of ethane in the high-temperature photolysis of acetaldehyde has been calculated from data on the rate of formation of methyl radicals. These results have been compared with the ethane in the reaction products as determined by analysis. A.

541.15 : 532.528 : 534.39

2204. The reaction sites in a field of stationary ultrasonic waves. O. LINDSTRÖM. Letter in *J. Chem. Phys.*, **19**, 1613–14 (*Dec.*, 1951).

An experiment is outlined in which an aqueous solution of KI and CCl_4 was subjected to stationary ultrasonic waves. Iodine was liberated in zones approximating to the nodes, which is consistent with the view that the reaction is connected with the cavitation process itself and not with gas bubbles produced by the cavitation. C. B. ALLSOPP

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.18 : 541.135.5

2205. The properties of the electrical double layer. II. The zero point of charge of AgI in water-acetone mixtures. E. L. MACKOR. *Rec. Trav. Chim. Pays-Bas*, **70**, 747–62. (*Sept.–Oct.*, 1951).

For Pt I, see Abstr. 9072 (1951). The change in the potential ϕ between the bulk of two phases can be measured with reasonable accuracy. A basic assumption, which is generally made in the model theory of the electrical double layer is that one knows the surface potential ψ. This inevitably leads to the conception of the χ potential of Lange-Verwey. This χ potential between AgI and solution is treated in the present article. The concentrations of the Ag^+ and I^- ions at the zero point of charge in water-acetone mixtures are measured. There is a sharp increase in this Ag^+ ion concentration in the mixture up to 10 mole % acetone. This shift can be explained by the oriented adsorption of acetone on AgI, creating a change in the χ potential. The change in the free enthalpy of solvation of the Ag^+ and I^- ions can be deduced from the concentration measured at the zero point of charge at higher acetone concentrations. The shift is compared with the influence of some surface-active substances on the polarized Hg electrode. The infer-

ence from it is that even in aqueous solutions the χ potential changes as a function of surface charge. A.

541.18 : 541.135.5

2206. The properties of the electrical double layer. III. The capacity of the double layer on Hg and on AgI. E. L. MACKOR. *Rec. Trav. Chim. Pays-Bas*, **70**, 763–83 (*Sept.–Oct.*, 1951).

A model of the double layer on the basis of the Gouy–Stern theory is given assuming the absence of chemisorption of counterions. The capacity K of the Stern layer is taken to be constant, but the χ potential located in the first water layer at the phase boundary is assumed to be a function of the surface charge. This theory is discussed using as an example the capacities of the Hg electrode in NaF solutions. The adsorption of Ag and iodide ions on AgI at different concentrations of $NaClO_4$ in water, 25% vol. and 100% vol. acetone were determined. The capacities of the double layer on AgI calculated from these adsorption curves are in many respects similar to the usual capacity curves of Hg. There are, however, some qualitative differences. The theory of Grimley and Mott of the double diffuse layer is discussed. Comparison with experiment shows the influence of the diffuse layer in solid AgI on the total capacity to be small. A.

541.18 : 541.135.5

2207. The properties of the electrical double layer. IV. The stability of the AgI sol in water-acetone mixtures. E. L. MACKOR. *Rev. Trav. Chim. Pays-Bas*, **70**, 841–66 (*Nov.*, 1951).

The electrolyte concentration at rapid flocculation of the AgI sol is measured in water-acetone mixture for $NaClO_4$, $Ba(ClO_4)_2$ and $La(ClO_4)_3$. There is a large drop in this value at high concentrations of acetone as is predicted in Verwey and Overbeek's theory of stability. At medium acetone concentrations the AgI sol is stabilized, contrary to expectation. The theory of stability is extended on the basis of a model with double layers of Gouy–Stern type on flat interacting parallel plates. This theory explains the measured values if one assumes an attraction of the van der Waals–London type. This attraction energy should be inversely proportional to $d^{1.6}$ instead of to the square of the inverse distance, as is calculated by de Boer and Hamaker. A.

541.183

2208. On reactions in monolayers. E. RIDEAL. *Proc. Roy. Soc. A*, **209**, 431–46 (*Nov.* 21, 1951).

Bakerian Lecture. Recent work reviewed on the behaviour of films on the surface of water and of aqueous solutions includes: (1) phase diagrams of the films; on dilute solutions and at large values of A (= area per molecule) the modified Boyle–Marriotte relationship $\pi A = 3kT$ is obeyed (π = surface pressure, k = Boltzmann's constant, T abs. temp.); (2) the use of monolayers, and of built-up multilayers, for investigating the structure of complex organic molecules, e.g. polypeptides, proteins, synthetic polymers; (3) the rates of reaction in monolayers including (i) the dependence of the velocity constant (and of the quantum efficiency in photochemical reactions) on the state of the film and hence on the orientation of its molecules; (ii) the formation of complexes between film molecules (e.g. proteins) and substrate molecules (e.g. 44′-dihydroxystilbene) by the process of film penetration (I); (iii) the effect of pH on I; (iv) the effect of ionic strength in the substrate on the rate of diffusion of molecules out of a film. The significance of these phenomena for biology is briefly touched on. S. J. GREGG

541.183

2209. Activated adsorption of hydrogen on nickel catalysts. C. G. A. SCHUIT AND N. H. DE BOER. Letter in *Nature* [*Lond.*] **168**, 1040–1 (*Dec.* 15, 1951).

Measurements of the adsorption of H_2 on a mixed nickel-silica catalyst (I) showed that the slow uptake of H_2 characteristic of activated adsorption (II) is only found when I contains oxygen, showing that II is merely adsorption on that part of a metal surface covered with O_2 or O. S. J. GREGG

541.183 : 536.421

2210. Melting point of adsorbed liquids. M. J. BROWN AND A. G. FOSTER. Letter in *Nature* [*Lond.*] **169**, 37 (*Jan.* 5, 1952).

The plot of $\log p$ (p = equilibrium pressure corresponding to pores 25Å in radius, calc. by the Kelvin equation) against $1/T$ (T = °K) shows a sharp break at 3·2°C, indicating a sharp melting-point at a temp. 6·8° < m.p. of the bulk liquid. S. J. GREGG

541.183.1 : 530.162

2211. Some notes on the statistical theory of adsorption. N. L. BALÁZS. *Physica*, **17**, 865–75 (*Oct.*, 1951).

A derivation is given for the Langmuir, Brunauer–Emmett–Teller, and Cassie adsorption isotherms with the help of the grand-canonical ensemble. This method justifies the approximations contained in the usual statistical treatments of adsorption. Furthermore, it is possible to reveal the implicit assumptions about the structure of the adsorbed layers contained in the kinetic derivations seemingly based only on the principle of detailed balancing. If one uses these assumptions one may deduce other types of adsorption isotherms probably exhausting the possibilities contained in these simple molecular models. A.

541.183.5 : 539.26

2212. An X-ray study of the action of oleic acid on lead. J.-J. TRILLAT AND S. BARBEZAT. *J. Rech. Cent. Nat. Rech. Sci.*, *No.* 16, 18–20 (1951) *In French.*

Below 23°c the lead oleate molecules stand perpendicular to the lead surface; above 23° they stand inclined to the surface. A. R. STOKES

CHEMICAL STRUCTURE 541.2/.6

541.24

2213. Determination of molecular masses by a kinetic method. W. MUND AND J. A. HERMAN. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 525–31 (*No.* 6, 1951) *In French.*

A microchemical method is described for the determination of molecular masses by measurement of the rate of gaseous flow through a small orifice. The following gases are employed: H_2, O_2, C_2H_4, C_2H_3Cl, CS_2, C_6H_6 and $CHCl_3$. H. H. HODGSON

541.56

2214. Note on the electron affinity of fluorine. R. B. BERNSTEIN AND M. METLAY. Letter in *J. Chem. Phys.*, **19**, 1612 (*Dec.*, 1951).

This is calculated on the basis of a new value for the heat of dissociation, 37·7 kcal/mole. The result agrees well with experiment. A. J. TAYLOR

541.62

2215. The isomers of cyclohexane. P. HAZEBROEK AND L. J. OOSTERHOFF. *Disc. Faraday Soc., No.* 10, 87–93 (1951).

The equilibrium between the rigid and the flexible isomer of cyclohexane is calculated. The results indicate that at ordinary temperatures the flexible isomer occurs at most to a very slight extent. At higher temperatures it may occur in concentrations which are large enough to allow an experimental confirmation. A.

541.653

2216. Optical rotation of polarized light by chemical compounds. W. R. BRODE. *J. Opt. Soc. Amer.*, **41**, 987–96 (*Dec.*, 1951).

Surveys the application of plane polarized light to the determination of the configuration of asymmetric organic compounds. The concept of asymmetric structures is discussed and the methods of separation of optical isomers have been indicated. Spectropolarimeters for the determination of rotatory dispersion curves are described and examples of normal and anomalous rotary dispersion curves are given. A.

541.66

2217. Heats of combustion and resonance energies of polynuclear aromatic hydrocarbons. A. MAGNUS, H. HARTMANN AND F. BECKER. *Z. phys. Chem.*, **197**, 75–91 (*No.* 1–2, 1951) *In German.*

Experimental heats of combustion are used to compare with valence theory the effect on resonance energy of (i) type of anellation, (ii) steric hindrance to planarity, (iii) hydration of C-atoms at mean positions. In (i) correlation is excellent except for phenanthrene-anthracene; from (ii) 1, 1′ binaphthyl is planar, 9–10 diphenylanthracene highly twisted; in (iii) good agreement. J. JACOBS

541.66

2218. The effect of chain length on the volumes, coefficients of expansion, and freezing temperatures of fractionated polystyrene. K. UEBERREITER AND G. KANIG. *Z. Naturforsch.*, **6a**, 551–9 (*Oct.*, 1951) *In German.*

The physical properties of polystyrene fractions of mol. wt. range 104–93450 have been examined.

W. R. ANGUS

541.66

2219. Steric effects of substituents in the neighbourhood of the central [atom of] carbon on the thermochromy of bis-β-naphthopyrylospiranes. P. RUMPF AND O. CHAUDÉ. *C.R. Acad. Sci.* [*Paris*] **233**, 1274–6 (*Nov.* 19, 1951) *In French.*

Steric analysis involving the coplanarity rule of mesomeric systems and the tension of cycles makes it possible to interpret the effect of the hydrocarbon type substitutents on the heats of the transformation of various pyrylospiranes into coloured forms.

F. LACHMAN

541.67 : 548.523

2220. A method for the calculation of the position of the magnetic ellipsoid in the β-naphthol crystal, according to data furnished by the method of oriented crystalline nuclei. J. BLANDIN. *C.R. Acad. Sci.* [*Paris*] **233**, 1299–301 (*Nov.* 19, 1951) *In French.*

See Abstr. 4476 (1950). The position of the magnetic ellipsoid may be completely determined knowing the geometric shape and parameters of the crystal. W. R. ANGUS

LABORATORY APPARATUS 542.1/.7

542.3

2221. A convenient micropipette. L. G. BARTH AND L. C. SZE. *Rev. Sci. Instrum.*, **22**, 978–80 (*Dec.*, 1951).

The pipette has an accuracy of about 0·02 microlitre. Advantages over previously described types of micropipettes are the relative ease of construction and the simple tools required, without sacrifice in accuracy of delivery. A.

542.48

2222. The distillation of lithium metal. L. F. EPSTEIN AND W. H. HOWLAND. *Science*, **114**, 443–4 (*Oct*, 26, 1951).

A method for the successful distillation in a glass system is described. The metal is heated in a stainless steel cup within the system by h.f. induction heating and care is taken to allow only vapour and not liquid Li to come into contact with the glass. It is remarked that observations have shown that the rate of reaction with air of the distilled Li, as for distilled Na, is less than for the more impure metals. S. WEINTROUB

CHEMICAL ANALYSIS 543/545

545.37

2223. Reproducible liquid junction for polarographic cells. H. J. GARDNER AND A. A. DIAMANTIS. Letter in *Aust. J. Sci.*, **14**, 23–4 (*Aug.*, 1951).

The ordinary type of liquid junction is found to be unsatisfactory in the polarography of organic substances, and half-wave potentials are rarely reproducible to values better than 5 mV. Impracticable also are the types: constrained diffusion, continuous mixture and free diffusion, but an agar-free diffusion junction (diagram included) is considered to be the most convenient type for polarographic work and gives a reproducibility of 0·5 mV. Data are given for coumarin and azobenzene. H. H. HODGSON

545.37 : 621.317.39

2224. A precision polarograph for chemical analysis. H. A. DELL AND C. H. R. GENTRY. *Electronic Engng*, **24**, 19–21 (*Jan.*, 1952).

The usual direct-reading dropping-mercury electrode polarograph is made more sensitive by the application of a c.r.t. to show the point of max. current in the life of each mercury drop. I_{peak} is then given by the c.r.t. calibration in volts and a series resistance. The simple circuit is modified to allow

for cell potential correction, the adjustment being made as the c.r.t. is watched. Another improvement is in the generation of a slave time-base by the mercury drops themselves. Overall accuracy is improved from $\sim 1\%$ to $0{\cdot}3\%$, with a precision of $0{\cdot}1\%$ in the usual working range. E. H. W. BANNER (R)

545.8

2225. A new method of magnetic analysis of oxygen. K. F. LUFT. *Z. angew. Phys.*, **3**, 300–3 (*No.* 8, 1951) *In German.*

An inhomogeneous magnetic field is used to determine the oxygen content of gaseous mixtures of various oxygen concentrations. The principle and theory of the method and some results obtained are given. W. R. ANGUS

545.822

2226. A possible extension of the density-difference method of spectrographic analysis. B. VERKERK. *J. Opt. Soc. Amer.*, **41**, 1017–22 (*Dec.*, 1951).

The density transformation according to Seidel, $D_t = \log [(d_0/d) - 1]$ results in a calibration curve that is nearly straight in the wavelength region normally used in spectrographic analysis. The properties of the "transformed density curve" are studied in detail and it is shown that by choice of favourable conditions the remaining curvature is negligible. This offers the possibility to extend the density difference method to the (H and D) density range $0{\cdot}1$–2. A.

545.824

2227. X-ray photoelectron spectrometer for chemical analysis. R. G. STEINHARDT, JR AND E. J. SERFASS. *Analyt. Chem.*, **23**, 1585–90 (*Nov.*, 1951).

An instrument is described which measures X-ray photoelectron intensities at energies from 6 to 17·5 keV and is shown to be capable of yielding qualitative and quantitative data for elements having atomic numbers greater than about 25. The instrument is a 180° magnetic deflection electron energy selector using a high-intensity X-ray tube for excitation and an ultra-thin window Geiger–Müller counter for detection. The potentialities of the instrument for performing atomic surface analyses appear to be considerable. A.

545.824

2228. Apparatus for vacuum X-ray fluorescence analysis of light elements. L. S. BIRKS. *Rev. Sci. Instrum.*, **22**, 891–4 (*Dec.*, 1951).

Air absorption in the conventional X-ray fluorescence analysis equipment limits detection to elements heavier than Ca. To avoid absorption of the longer-wavelength X-rays from lighter elements, a vacuum system, or one filled with H_2 or He, is required. A vacuum apparatus has been developed for the analysis of elements from Mg to Ti. It contains the X-ray tube for exciting fluorescence; a specimen holder for 6 specimens; a collimator to limit the fluorescent radiation to a parallel beam; and a single-crystal, Geiger counter spectrometer to analyse the radiation. A pressurized, double-film, nitrocellulose window is used for the Geiger counter because the usual mica windows are opaque to radiation from elements lighter than S. For Ca K_α, the increase in intensity resulting from evacuating the chamber is 100-fold, with far greater increases for the lighter elements. Alkali halides and gypsum were tested as analysing crystals. An application of the equipment to the measurement of S in oil indicates that $0{\cdot}5\%$ S can be detected with $\pm\ 0{\cdot}03\%$ accuracy in 5 to 10 min. A.

CRYSTALLOGRAPHY 548

548.0 : 535.52

2229. Dipole and quadrupole radiation fields in non-cubic crystals. K. H. HELLWEGE. *Z. Phys.*, **131**, 98–112 (*No.* 1, 1951). Shorter version in *Naturwissenschaften*, **38**, 460 (*No.* 19, 1951) *In German.*

See Abstr. 7369 (1951). The radiation fields for dipole and quadrupole radiation are derived. The dipole radiation has a p-fold symmetry in crystals of symmetry $p \leqslant 2$, but has rotational symmetry for crystals with $p > 2$. Similarly the quadrupole radiation has a p-fold symmetry in crystals with $p \leqslant 4$ and rotational symmetry for crystals with higher p. An experimental procedure is indicated for distinguishing between electric dipole radiation, magnetic dipole radiation and electric quadrupole radiation, and an example is given of a likely case of quadrupole radiation. J. A. FRANKS

548.0 : 539.373

2230. Investigation of the gliding process in ionic crystals by prismatic punching. A. SMAKULA AND M. W. KLEIN. *Phys. Rev.*, **84**, 1043–62 (*Dec.* 1, 1951).

The prismatic punching method applies a unidirectional stress on a very small surface (approximately $0{\cdot}001$ cm^2) of a crystal lying on a support which is softer than the crystal itself. The method is very convenient for low and high temperature and for small samples. The glide system of thallium bromoiodide crystals determined by the prismatic punching method contains dodecahedron planes (110) as glide planes and cubic planes [001] as glide directions. The width of the glide bands ranges from 1 to 5 microns. The stress-strain curve shows a linear relation between the shear angle δ and the applied stress $\sigma(\delta = a'\sigma + b)$. The creep takes place according to the exponential law ($\delta = at^m$). The glide bands have to be displaced a distance of about 100 ions at room temperature and about 15 ions at $-$ 190°C before rupture takes place (plastic limit). Prismatic punching on sodium chloride crystals produces gliding along dodecahedron planes (110) in [110] direction. Apparent cleavage of sodium chloride crystals along dodecahedron planes and normal cleavage along cubic planes are explained as ruptures between neighbouring glide planes. A.

548.0 : 539.373

The crystallographic aspect of slip in body-centred cubic single crystals. *See Abstr.* 2110

548.2

2231. Crystal types of pure hydrocarbons in the paraffin wax range. E. W. CLARKE. *Industr. Engng Chem.*, **43**, 2526–35 (*Nov.*, 1951).

548.24

2232. Barium titanate twinning at low temperatures. R. G. RHODES. *Rep. Brit. Elect. Res. Ass., Ref. L/T* 244, 10 *pp.* (1950).

Crystals of $BaTiO_3$ have been studied by X-ray methods down to liquid air temperatures, and the present report describes the results obtained and amplifies the conclusions already set out briefly [Abstr. 6158 (1950)]. A.

548.5

2233. A method of growing single crystals of lead telluride and lead selenide. W. D. LAWSON. *J. Appl. Phys.*, **22**, 1444–7 (*Dec.*, 1951).

Single crystals of lead telluride measuring up to 1¼ cm diameter and 6 cm long have been grown in sealed silica crucibles by the Bridgman–Stockbarger method of lowering a melt slowly through a freezing level. The crystals have been grown for the purpose of testing the semiconducting and applied properties of lead telluride in that form. Extreme purity of the materials and cleanliness of the crucible have been found essential for successful growth. X-ray tests have shown that the specimens are single crystals. The purest crystal grown so far had a conductivity corresponding to an electron concentration of 5×10^{14} per cc. Attempts to introduce excess of one of the constituents—lead or tellurium into the crystal lattice during growth have not so far been successful. A.

548.5

2234. Microscopic studies on beryl crystals. II. Dislocations and the growth of $\{10\bar{1}0\}$ prism faces. L. J. GRIFFIN. *Phil. Mag.*, **42**, 1337–52 (*Dec.*, 1951).

For Pt I, see Abstr. 8344 (1951). It is shown that the type of growth predicted by the dislocation theory of growth takes place on $\{10\bar{1}0\}$ faces of beryl. The growth layers, in general, produce a complex topography. The behaviour of layers at surface obstacles is discussed. Examples are given of the propagation of a dominant layer group past lines of dislocations, and inactive dislocation groups, and the mode of propagation by cross-linking is discussed. Typical examples of lineage boundaries and limited slip zones are shown; these features are observed as lines of dislocations. The dependence of growth rate of the layers on crystallographic orientation is considered. The types of layer structure observed on natural and synthetic crystals are compared. It is shown that the dislocation theory of growth can be applied to give such information as the supersaturation and temperature at which growth took place. A.

548.5

2235. Application of dislocation theory to the polytypism of silicon carbide. V. VAND. *Phil. Mag.*, **42**, 1384–6 (*Dec.*, 1951).

Polytypism of silicon carbide can be understood if the assumption is made that the crystal grows out of the primary nucleus as a single sheet several atomic layers in thickness. The sheet winds itself spirally upwards along a bunch of screw dislocations which are situated at the spiral axis. If there are stacking faults in the original growth layer, they repeat themselves with the periodicity of the pitch of the screw throughout the crystal and thus determine the type and the dimensions of the unit cell. Similar typism occurs in graphite and possibly in diamond and other substances. A.

548.5

2236. Dislocations in thin plates. J. D. ESHELBY AND A. N. STROH. *Phil. Mag.*, **42**, 1401–5 (*Dec.*, 1951).

The stress due to a screw dislocation passing normally through an infinite plate or a disk is largely confined to the neighbourhood of the dislocation line, in contrast to the case of a dislocation in an infinite medium. Two screw dislocations in a plate attract or repel one another with a short-range force in place of the inverse first power law for infinite parallel dislocations. The stress due to an edge dislocation is not essentially different in the plate and infinite body so long as the plate remains flat, but in some circumstances the stress may be largely relieved by buckling of the plate. A.

548.5

2237. The growth of cadmium iodide crystals. I. Dislocations and spiral growth. A. J. FORTY. *Phil. Mag.*, **43**, 72–81 (*Jan.*, 1952).

Evidence is given that CdI crystals grow from a low degree of supersaturation by the dislocation mechanism. Sequences of photographs illustrate the stages in the growth of the crystal plates. The screw dislocations are not simple but are groups of simple dislocations. The kinking of step-lines is explained by the interaction of screw dislocation groups of different strengths. The properties of large screw dislocation groups in the crystal plates are discussed. A.

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

2238. The distribution of the metal ions in the spinel lattice and its influence on the physical properties. E. J. W. VERWEY, P. B. BRAUN, E. W. GORTER, F. C. ROMEIJN AND J. H. VAN SANTEN. *Z. phys. Chem.*, **198**, 6–22 (*No.* 1–4, 1951) *In German.*

An account of the structures and properties of spinel minerals. The occurrence of normal or inverse spinels is discussed and illustrated by the use of a heteropolar model. In the inverse spinels ordering is particularly important. The electrical properties of Fe_3O_4 and Mn_3O_4 are considered and the magnetic properties of simple ferrites and their mixed crystals with zinc ferrite are discussed in terms of Neel's theory. The influence of the angle (Fe–O–Fe) on the indirect exchange forces is shown to be in agreement with Anderson's theory. A. E. DE BARR

548.7

2239. The atomistic picture and the band model of crystals. F. STÖCKMANN. *Z. phys. Chem.*, **198**, 215–31 (*No.* 5–6, 1951) *In German.*

The corpuscular picture (Heitler–London) and band model (Bloch–Brillouin) which can both be used in the description of characteristic properties of electrons in crystals are compared on the basis of the electron theory. Both show themselves as complementary although one model may suit particular crystals more than the other, and several instances are given. The ideas are further developed to give a simple explanation of the weak *F*-centre absorption in alkali halide crystals. C. A. HOGARTH

548.7

2240. Insertion of Tl^+ into NaCl and KCl. P. BRAUER. *Z. Naturforsch.*, **6a**, 560–1 (*Oct.*, 1951) *In German.*

Presents the results of a theoretical determination of lattice energies when Tl^+ is built into alkali halogenides with an NaCl lattice. It has been found that the energy required for the insertion of Tl^+ into NaCl is 2·09 eV, while the respective figure for KCl is only 0·37 eV. It is suggested that this difference explains the fact that KCl, when crystallizing out of a Tl^+-containing solution, entrains Tl^+ and fluoresces, while in the case of NaCl the Tl^+ remains in the mother liquor. F. LACHMAN

548.7

2241. Outer Brillouin zones for face-centred and body-centred cubic lattices. J. F. NICHOLAS. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 953–6 (*Nov.*, 1951).

In order to resolve some inconsistencies in the literature on the second Brillouin zones of cubic lattices, the shapes of these zones have been recalculated. The results, together with descriptions of the third and fourth zones, are given. A.

548.7

2242. A dislocation reaction in the face-centred cubic lattice. W. M. LOMER. *Phil. Mag.*, **42**, 1327–31 (*Nov.*, 1951).

Energy relations are set up for dislocations on two intersecting slip planes in cubic crystals. It is shown that the dislocations can attract one another and combine to form a sessile dislocation [Abstr. 7325 (1949)] which may act as an immobile stress nucleus, hardening the crystal. J. A. FRANKS

548.7

2243. A note on the propagation of excitation in an idealized crystal. W. R. HELLER AND A. MARCUS. *Phys. Rev.*, **84**, 809–13 (*Nov.* 15, 1951).

It is shown that, in insulators, overlapping of the electronic wave functions of near-by crystal constituents is not necessary for effective transfer of excitation energy by the "exciton" mechanism. The electromagnetic interaction of the "virtual" dipoles of the transition is sufficient to give rise to such transfer characterized in cubic crystals by a wave number **k**, and an anisotropic effective mass, given in order of magnitude by the ratio electronic-mass/oscillator-strength of transition. Implications and limitations of the calculation are discussed. A.

548.7

2244. Variation of lattice frequencies with concentration in molecular mix-crystals. R. R. AGGARWAL AND B. D. SAKSENA. *J. Chem. Phys.*, **19**, 1480–4 (*Dec.*, 1951).

Assuming a unique linear periodic lattice for a non-ionic molecular mix-crystal, the lattice frequencies of the translational and rotational modes have been calculated for several concentration ratios of the two components. The observed variation in frequency in such crystals has been explained. The calculations also require that additional frequencies, not yet observed, should appear in Raman and infrared spectra. A.

548.7

2245. The concentration of molecules on internal surfaces in ice. E. J. MURPHY. *J. Chem. Phys.*, **19**, 1516–19 (*Dec.*, 1951).

The experimental expression for the "local conductivity" of ice is given. This expression has two terms, one of which has already been discussed and brought into close relation with the structure of ice, that is, with its heat of sublimation and its lattice constant. This paper brings out another relation, deriving it from the second term of the experimental expression. It is concluded from an analysis outlined here that the second term of the local conductivity gives the concentration of molecules in "internal surfaces." For the specimen of ice to which this method was applied the concentration of molecules on internal surfaces was $1{\cdot}03\times10^{17}$ molecules/cc. This is proposed as a new method of studying imperfections (internal surfaces) in dielectric crystals. It is not dependent upon the regularity of the imperfections, as in X-ray diffraction methods, or upon the connectivity of the system of internal surfaces, as in direct current conduction. A.

548.7

2246. On the generation of vacancies by moving dislocations. F. SEITZ. *Adv. Phys.*, **1**, 43–90 (*Jan.*, 1952).

New experiments of Molenaar and Aarts, Blewitt and others seem to confirm the view of the author, previously based only on the experiments of Gyulai and Hartly and Stepanow on sodium chloride, that vacant lattice sites, and possibly interstitial atoms, are generated during plastic flow in ductile crystals, particularly in metals. It is pointed out that the average temperatures near a moving dislocation are probably not sufficiently high to evaporate vacant lattice sites or interstitial atoms as a result of thermal effects alone. Instead, one apparently must conclude that the imperfections are generated either by purely geometrical means during the looping of dislocations about appropriate obstacles, as the result of dynamical instability in the motion of a dislocation, possibly near a jog, or in the very high thermal pulses or "spikes" which are generated either in the zone where two dislocations of opposite sign annihilate one another or near impediments where dislocations are strongly curved. It is pointed out that a pair of vacancies is probably stable near room temperature and may diffuse more rapidly than a single vacancy. It is

also proposed that vacancies retained during quenching of Al–Cu alloys and those generated by cold-work play an important role in the precipitation process. The origin of work hardening in single crystals is discussed and several alternative interpretations, which involve the impediment of Frank–Read generators either directly or indirectly as a consequence of the generation of vacancies, are presented. The importance of prismatic dislocations formed by condensation of vacancies is restated. The role that vacancies formed by cold-work may play in determining the stored energy and decrease in density and in affecting processes such as creep and the hardening of latent slip planes is also discussed. Finally a few experiments are proposed, typical of those which could prove decisive in isolating the influence of vacancies. A.

548.7

2247. Response of synthetic quartz to X-ray irradiation. C. S. Brown and L. A. Thomas. Letter in *Nature* [*Lond.*] **169,** 35–6 (*Jan.* 5, 1952).

Experiments show that darkening of quartz with irradiation is associated with impurities or strain: pure synthetic crystals show no darkening.

A. R. STOKES

548.7 : 535.375.5

The first order Raman effect in crystals, particularly in diamond. *See Abstr.* 1663

548.7 : 535.43

The scattering of light in crystals and the nature of their vibration spectra. *See Abstr.* 1686

548.7 : 536.631

2248. The vibration spectra of crystals and the theory of their specific heats. C. V. Raman. *Proc. Indian Acad. Sci. A,* **34,** 141–51 (*Sept.*, 1951).

The enumeration of wave-patterns within an enclosure on a scale of wavelengths or frequencies presupposes that the waves are perfectly undamped and that the enclosure is perfectly reflecting. In any material medium, however, wave-propagation is necessarily damped and such damping may be so enormous as altogether to preclude wave-propagation. It follows that it is not permissible to identify the modes of atomic vibration in crystals with wave-patterns. Since the specific heat theories of Debye and of Born-Karman are based on such identification, they cannot be sustained. For any mechanical model to represent the dynamic behaviour of a crystal, it is necessary that it should satisfy the requirements for dynamic similarity. When these requirements are satisfied, the behaviour of the model does not support the ideas underlying the Debye and Born-Karman theories, but on the other hand agrees with the results of the theory of the dynamics of crystal lattices put forward by the writer in 1943. The phenomena of light-scattering observed in crystals are also discussed, and it is shown that the experimental facts are incompatible with the ideas underlying the Born-Karman theory. A.

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr.* 2157–64

548.732

2249. X-ray diffraction by a crystal possessing periodicities within the unit cell. J. W. Jeffery. *Proc. Phys. Soc.* [*Lond.*] *A,* **64,** 1003–6 (*Nov.*, 1951).

The Fourier transform of a crystal is used to explain the appearance of the X-ray reflections from the true crystal lattice of tricalcium silicate as satellites of the strong reflections corresponding to a pseudo-lattice. Similar but more general diffraction effects are also discussed. A.

548.732

2250. One- and two-dimensional X-ray diffraction. B. D. Cullity. *Amer. J. Phys.*, **19,** 500–6 (*Dec.*, 1951).

A description is given of the diffraction phenomena from crystals so small in some directions that they may be considered essentially as one- or two-dimensional crystals. The basic theory of X-ray diffraction, in terms of the Ewald construction in the reciprocal lattice, is first presented for the case of a three-dimensional crystal and then extended to crystals consisting only of a plane of atoms one layer thick or of a linear chain of atoms. Intermediate cases are then considered and experimental methods of observing these phenomena are discussed. Finally, examples are given of one- and two-dimensional crystals which have been found in layer lattices, fibrous materials, supersaturated metallic solid solutions and metal crystals having stacking errors. A.

548.732 : 548.736.3

2251. Atomic size effect in the X-ray scattering by alloys. B. E. Warren, B. L. Averbach and B. W. Roberts. *J. Appl. Phys.*, **22,** 1493–6 (*Dec.*, 1951).

In a random solid solution, if the two atoms have appreciably different sizes, the nearest-neighbour distances and to a lesser extent the higher neighbour distances will be of 3 kinds, r_{AA}, r_{AB} and r_{BB}. The effect produces modulations in the diffuse intensity similar to those produced by short-range order. The size effect is important when the difference in scattering power is large, the difference in size is large and the short-range order is small. The size effect is illustrated by a single crystal pattern of Cu_3Au and a powder pattern of Ni_3Au_2. An asymmetry in the wings about a fundamental reflection is a result of the size effect. A.

548.732 : 539.4.016.2

2252. The diffraction pattern of cold worked metals. I. The nature of extinction. W. H. Hall and G. K. Williamson. *Proc. Phys. Soc.* [*Lond.*] *B,* **64,** 937–46 (*Nov.*, 1951).

The influence of crystal perfection on extinction is briefly discussed and the possible corrections given. Experimental results for chemically produced Cu and annealed Al filings have been obtained with a Geiger-counter spectrometer using monochromatic radiation. The intensity measurements, and for Cu the experimentally determined particle size, were inconsistent with the views that primary extinction occurred, but could be interpreted wholly in terms of secondary extinction, the corrected f values agreeing within $\pm 2\%$ with accepted values. Evidence to show that annealed metals contain residual lattice strain is advanced, in accord with the dislocation theory, and

it is suggested that secondary extinction will predominate over primary extinction in all crystals containing such dislocations. A.

548.732 : 539.4.016.2

2253. The diffraction pattern of cold worked metals. I. Changes in integrated intensity. W. H. HALL AND G. K. WILLIAMSON. *Proc. Phys. Soc.* [*Lond.*] *B*, **62**, 946–53 (*Nov.*, 1951).

Measurements have been made, using a Geiger-counter spectrometer, of the changes produced by cold work on the integrated intensities in the Debye–Scherrer spectrum of Al. It is shown that cold work reduces the integrated intensity of all reflections, this decrease being exactly compensated by a rise in the diffuse background scatter, so that the total reflected intensity is unchanged. These results are at variance with those of previous workers, but the discrepancy can be readily explained by the absence of a correction for extinction in previous work. Brief reference is made to measurements of line width, and it is shown that the results support the dislocation theory of plastic deformation. A.

548.733

2254. A scanning device for precision determination of lattice parameters at constant temperatures. M. E. STRAUMANIS AND E. Z. AKA. Note in *Rev. Sci. Instrum.*, **22**, 843–4 (*Nov.*, 1951).

The device oscillates a powder specimen parallel to its axis as well as rotating it, and thus reduces line spottiness on the photograph. It is designed to work in a thermostat-regulated camera. A. R. STOKES

548.733

2255. An X-ray spectrometer for polymer studies. S. KRIMM AND R. S. STEIN. *Rev. Sci. Instrum.*, **22**, 920–4 (*Dec.*, 1951).

A Geiger counter X-ray spectrometer has been designed and constructed suitable for the quantitative study of crystallinity and orientation in polymers and of relaxation phenomena associated with these properties. The instrument is designed for use with crystal monochromatized or filtered radiation, and has such features as Soller slit collimation, means of studying the materials above room temperature, and a Geiger counter monitor on the X-ray beam. The spectrometer, pertinent techniques and typical results are described. A.

548.733 : 537.531 : 771.534.53

Characteristics of photographic film used in X-ray diffraction studies. *See Abstr.* 2338

548.733 : 541.124

2256. *In situ* X-ray diffraction studies of heterogeneous reactions. M. A. MOSESMAN. *J. Amer. Chem. Soc.*, **73**, 5635–9 (*Dec.*, 1951).

An apparatus embodying a metallic microreactor of approximately 0·002-ml capacity, fabricated from high purity, machinable beryllium rod, has been developed and utilized for the investigation of the changes that occur in solid materials through chemical interaction with gaseous reactants in a flow system as revealed by *in situ* X-ray powder diffraction patterns. The construction of the apparatus is such as to permit operations at pressures and temperatures as high as 11 atmospheres and 650° respectively, and flow rates as low as 1·0 ml/hr. The X-ray diffraction data obtained in the application of this apparatus to the determination of the stable oxidation states of iron in an ammonia synthesis catalyst and of molybdenum in bulk and alumina-supported molybdenum trioxide in reducing and oxidizing atmospheres identify Fe_3O_4, FeO and Fe in the former instance and MoO_3 and MoO_2 in the latter instances during the course of the reactions observed under the imposed operating conditions. A.

548.733 : 621.386.1

2257. A demountable X-ray tube for crystallographic studies. C. LEGRAND. *J. Rech. Cent. Nat. Rech. Sci., No.* 16, 31–4 (1951) *In French.*

The focus can be adjusted with the tube working and its image observed on a built-in fluorescent screen. The focus is about 1·0×0·25 mm, with maximum loading 500 W/mm² on a copper anti-cathode. The construction is described in fair detail. A. R. STOKES

548.734.842

2258. The experimental determination of the distribution of the valence electrons in crystals. A. I. SNOW. *Acta Cryst.*, **4**, 481–2 (*Nov.*, 1951).

A discussion of the work of Ageyev and others on Al, Cu, Ni and NiAl [Abstr. 1244 (1949)]. The "bridges" between atoms found by Ageyev could be due solely to the large artificial temperature factors used. A. R. STOKES

548.735

2259. Finding the coördinates of the atoms in the unit cell of a crystal by means of the F^2-series. A. I. KITAĬGORODSKIĬ. *Zh. Eksper. Teor. Fiz.*, **21**, 717–20 (*No.* 6, 1951) *In Russian.*

It is shown that the midpoint of any interatomic vector of the F^2-series is a centre of inversion which connects two groups of points each of which represents the structure of the crystal. The possibility of uniquely deriving a structure from its representation as a 3-dimensional F^2-series has been shown by Buerger [Abstr. 3517 (1950)], and the practical schedule for doing this which is developed here follows observations by Sanadze and Zhdanov [Abstr. 9117 (1950)]. Three-dimensional F^2-series are necessary, and a calculation is adduced showing that the practical solution of a structure (all the atoms of which are approximately the same weight) is likely to be possible. A. L. MACKAY

548.735.6

2260. X-ray extinction in type II diamonds and topaz. G. E. PRINGLE AND A. G. PEACE. Letter in *Nature* [*Lond.*] **169**, 36 (*Jan.* 5, 1952).

The contrast of lines on divergent-beam diffraction photographs is related theoretically to the degree of mosaic-block disorientation in the crystal. A. R. STOKES

548.736.1

2261. The symmetry of graphite. J. S. LUKESH. Letter in *Phys. Rev.*, **84**, 1068 (*Dec.* 1, 1951).

See Abstr. 1498 (1951). Precession photographs taken with Mo *K* α-radiation show further evidence of twofold rather than sixfold symmetry. A. R. STOKES

548.736.1 : 536.413 : 539.155.4

2262. Precision determination of lattice parameter, coefficient of thermal expansion and atomic weight of carbon in diamond. M. E. STRAUMANIS AND E. Z. AKA. *J. Amer. Chem. Soc.*, **73**, 5643–6 (*Dec.*, 1951).

Four diamond samples from the Belgian Congo were used for the investigation. Spectrographic analysis revealed the presence of traces of fifteen elements in the samples. The lattice parameter determinations were carried out by means of the asymmetric method, with a 64 mm. precision camera in a thermostat at five constant temperatures (10, 20, 30, 40 and 50°). The powder mounts, 0·12 mm in diameter, were translated and rotated during the exposure in order to assure uniformity of the lines. Only the (331)-Co$K\beta_1$ line was used for the determinations. The three clear white diamond samples showed the same lattice parameter: 3·55960 ± 0·000016kX (3·56679 Å) at 20°, corrected for refraction. The accuracy of determination was better than 1 : 200 000. The parameter of gray boart was 3·55968 ± 0·00003kX at 20°. The thermal lattice expansion coefficient, as determined from all samples, was $(1{\cdot}38 \pm 0{\cdot}12) \times 10^{-6}$. The atomic weight of carbon in the clear diamond samples was 12·0096 (the average value of the densities obtained by Bearden and Tu being used for the calculations). This weight is 0·003% lower than the chemical atomic weight, but is well within the error limit of the method. Therefore, the diamond lattice is sound and the method of lattice constant determination applied is an absolute one. Comparison with the work of other authors shows that clear white diamonds usually have the same lattice constants as noted above. Thus, the impurities are included mechanically. However, a very limited formation of a solid solution with silicon or other elements is not excluded (gray boart). A.

548.736.3

2263. Polymorphism of tungstic anhydride studied at high temperatures by means of X-rays. J. WYART AND M. FOËX. *C.R. Acad. Sci.* [*Paris*] **232**, 2459–61 (*June* 25, 1951) *In French.*

WO_3 at room temperature is triclinic, almost orthorhombic. Powder photographs show that it changes to orthorhombic at 350°C and to tetragonal at 735°C. Lattice parameters are given. A. R. STOKES

548.736.3

2264. Lattice defects in silver bromide at room temperature. H. D. KEITH AND J. W. MITCHELL. *Phil. Mag.*, **42**, 1331–2 (*Nov.*, 1951).

Measurements of lattice parameter (5·7633kX) and density (6·4799 g cm^{-3} at 18°c) give no positive evidence of vacant lattice sites. A. R. STOKES

548.736.3

2265. Uranium sesquicarbide. M. W. MALLETT, A. F. GERDS AND D. A. VAUGHAN. *J. Electrochem. Soc.*, **98**, 505–9 (*Dec.*, 1951).

U_2C_3 has been found to exist as a stable compound below about 1 800°c. At higher temperatures, it decomposes into UC and UC_2. It has not been produced directly from the melt but only by heating a mixture of UC and UC_2 between 1 250° and 1 800°c. A slight amount of stressing, even as little as that incidental to handling a specimen, is necessary to initiate the reaction. An experimentally determined density of 12·7 g/cm^3 agrees very well with a density of 12·88 g/cm^3, calculated from X-ray data. The crystal structure of the compound had been found to be body-centred cubic, having a space group symmetry $I\bar{4}3d$ and a unit-cell dimension of $a_0 = 8{\cdot}088 \pm 0{\cdot}001$ Å. A.

548.736.3

2266. Low temperature polymorphic transformation in WO_3. B. T. MATTHIAS AND E. A. WOOD. Letter in *Phys. Rev.*, **84**, 1255 (*Dec.* 15, 1951).

The polarizing microscope and X-ray powder and Laue photographs show a transformation at −50°c, below which WO_3 has higher symmetry than at normal temperatures and is ferroelectric.

A. R. STOKES

548.736.3 : 541.57

The covalent bond length of mercury-chlorine. *See Abstr.* 1292

548.736.4 : 535.347

2267. Structure-optical studies. III. Smeared X-ray layer lines from periodide crystals. C. D. WEST. Letter in *J. Chem. Phys.*, **19**, 1432 (*Nov.*, 1951).

For Pt II, see *J. Chem. Phys.*, **17**, 219 (1949). Smeared layer lines and strong positive dichroism indicate the existence of linear polyiodine chains in periodide crystals. A. R. STOKES

548.736.5 : 539.164.93

2268. On the spontaneous destruction of the crystalline lattices of radioactive minerals. P. PELLAS. *C.R. Acad. Sci.* [*Paris*] **233**, 1369–71 (*Nov.* 26, 1951) *In French.*

The effect of α-radiation on partially covalent and also on ionic lattices has been qualitatively observed, and the formula for the flux modified to take account of the effect of the recoil nucleus, which is 10 times more "destructive" than an α-particle. Figures are quoted for allanite, fergusonite and thorite.

A. J. KENNEDY

GEOPHYSICS 55

550.34 : 534.21

Elastic waves through a packing of spheres. *See Abstr.* 1555

550.346 : 551.596

2269. Sound waves in the atmosphere generated by a small earthquake. H. BENIOFF, M. EWING AND F. PRESS. *Proc. Nat. Acad. Sci.* [*Wash.*] **37**, 600–3 (*Sept.*, 1951).

This investigation is believed to represent the first analysed case of air-coupled waves due to a natural earthquake. It is shown that conditions necessary for such occurrences are not uncommon, so that future

data will be forthcoming. The earth shock, of magnitude 5·6, took place on January 24, 1951, in the Imperial Valley in California at a distance of 265 km from Pasadena, where it was recorded by the microbarograph, but not by the seismographs (a fact illustrating a fundamental reciprocity principle connected with air-coupled waves). The disturbance lasted about five minutes, and its detailed theoretical interpretation leads to Rayleigh waves of period 0·9 sec, which crossed the weathered sedimental layers of the valley at a speed of 0·10 km/sec, radiating compressional waves into the air as they went; these went up vertically, with a mean velocity of 0·305 km/sec, to a height of 40 km, and travelled then horizontally with 0·326 km/sec to Pasadena before descending. The agreement of calculated and observed travel-times is satisfactory, particularly in view of the gradual nature of the beginning and end of the signal, the uncertainty in the elastic constants used in the theoretical curves, and the simplification of the aerial path employed. A. BEER

550.38

2270. [An apparatus for] recording small changes in the earth's magnetic field. H. DÜRSCHNER. *Ann. Géophys.*, **7**, 199–207 (*No.* 4, 1951) *In French.*

A magnetometer magnet is placed between two Helmholtz coils providing a compensating field and the reflection from a mirror fixed to the magnet is recorded by means of two photo-electric cells on a milliammeter. Details of the apparatus are given, its sensitivity is discussed and results of some measurements are shown. E. P. WOHLFARTH

550.38 : 621.317.45

2271. Stroboscopic earth inductor compass. S. A. SCHWARTZ. *Elect. Engng* [*N.Y.*] **70**, 1001–3 (*Nov.*, 1951).

The principle of operation is described of a sensitive, quick-acting and reliable compass for use in light aircraft. A small coil carrying a compass card is rotated at high speed in the earth's field. The sinusoidal e.m.f. generated is amplified, squared and differentiated to trigger a h.v. pulse generator driving a strobotron which illuminates the compass card. The numbers on the scale appear to remain stationary but the relative phase of the scale depends on the direction in which the earth's field cuts the spinning coil. The coil consists of 1 000 turns of No. 40 enamelled wire placed on a loop of 2 in² effective area. It is intended that the loop be rotated by the airstream or by a small electric motor mounted sufficiently far away not to cause disturbance. The speed is 3 600 r.p.m. and the output 0·01 V. The amplifier delay introduces a constant correctable error of 10 degrees while a 50% increase in coil speed produces an error of 3 degrees. Recommendations for future development are appended. S. C. DUNN (R)

550.383

2272. Measurements of the variation with depth of the main geomagnetic field. S. K. RUNCORN, A. C. BENSON, A. F. MOORE AND D. H. GRIFFITHS. *Philos. Trans A*, **244**, 113–51 (*No.* 878, 1951).

The main geomagnetic field is attributable either to some deep-seated phenomena within the earth or to a fundamental property of rotating matter in which the source of the field would be distributed throughout the whole earth. The two types of explanation predict a different variation of the components of the main field with depth within the crust and can be tested by direct measurement in suitable localities. Measurements in five mines in northern England are presented and discussed and they provide evidence in favour of the core theory. A.

550.384

2273. The direction of the earth's magnetic field at Carthage in the Punic and Roman eras as measured on walls of furnaces. E. THELLIER AND O. THELLIER. *C.R. Acad. Sci.* [*Paris*] **233**, 1476–8 (*Dec.* 3, 1951) *In French.*

Values of the angles of declination and inclination were obtained with an error $< 1°$. At 146 B.C. $D = 0° 30'$ W, $I = 58°$; at A.D. 300 $D = 1° 15'$ W, $I = 51°$. E. P. WOHLFARTH

550.834

2274. Neutron logging of drill holes: the neutron-neutron method. C. W. TITTLE, H. FAUL AND C. GOODMAN. *Geophysics*, **16**, 626–58 (*Oct.*, 1951).

Experiments were performed to determine the distribution of thermal neutrons and of indium resonance neutrons in continuous hydrogenous media and in pipes passing through hydrogeneous media. Included in the study were water, brine, mixtures of sand and water, and mixtures of sand and brine. Experiments in a continuous typical barite drilling mud showed that the neutron distributions were essentially the same as in water. Also, from the point of view of these experiments, oil and fresh water are nearly identical. These experiments show that well fluid (and, by inference, cement) imposes serious limitations on the sensitivity and accuracy of the neutron-neutron logging method. The indium resonance neutron response (or, in general, the intensity of epithermal neutrons) is a more reliable indicator of hydrogen content of the formation than is the thermal neutron response. The neutron-neutron method of chlorine determination was found to be not sensitive enough to be useful with brines of the concentrations ordinarily found in reservoirs. A.

550.838 : 538.3

2275. A conducting sphere in a time varying magnetic field. J. R. WAIT. *Geophysics*, **16**, 666–72 (*Oct.*, 1951).

The secondary magnetic fields are evaluated for the case of a conducting sphere in a relatively poorly conducting medium under the influence of a time varying magnetic field. The sinusoidal and step function responses are both considered. The responses so calculated are thought to be useful in a geophysical prospecting method which utilizes the transient behaviour of induced eddy currents in a highly conducting ore zone. A.

550.93 : 539.155.2

2276. The primeval lead isotopic abundances and the age of the earth's crust. R. A. ALPHER AND R. C. HERMAN. *Phys. Rev.*, **84**, 1111–14 (*Dec.* 15, 1951).

Nier's determinations of Pb isotopic abundances in common Pb ores have been the subject of considerable study in connection with attempts to calculate the age of the earth. The importance of the age of the earth

n fixing the age of the elements has led us to remark n the very high precision frequently attributed to the ormer age determinations. A calculation is presented which yields a rough maximum age of the earth, namely, $t(\max) = 5{\cdot}3$ billion years. The primeval Pb isotopic abundances have been estimated and briefly discussed in the light of nuclear systematics. A.

ATMOSPHERE . METEOROLOGY 551.5

551.508.15

2277. On the automatic chemical determination of atmospheric ozone. I. G. BOWEN AND V. H. REGENER. *J. Geophys. Res.*, **56**, 307–24 (*Sept.*, 1951).

A chemical method for the automatic and quantitative recording of atmospheric ozone near the ground, from aircraft, or by means of sounding balloons, is described. A network of surface ozone recording stations is now being established in New Mexico and one airborne unit has been flown in an aeroplane. Preliminary recordings are communicated. A.

551.508.7 : 523.275

Methods of measuring humidity and testing hygrometers. *See Abstr.* 1530

551.508.94

2278. An apparatus for simultaneous registration of potential gradient and air-earth current (description and first results). H.-W. KASEMIR. *J. Atmos. Terr. Phys.*, **2**, 32–7 (*No.* 1, 1951).

The CR constants are chosen in such a way that minor changes of the atmospheric electric elements in question are suppressed and the diurnal variations can readily be seen from the records. Modern technical means such as six-channel recorders, electrometer tubes, and low loss cables make it possible to register a great range of potential gradient and air-earth current. The apparatus is convenient as to dimensions and weight so that it can be used on mountain observatories and expeditions without difficulty. Preliminary results obtained on mountain peaks are described, which will help in the interpretation of such records. A.

551.510.41

2279. On the distribution of atmospheric sodium. G. KVIFTE. *Geofys. Publ.*, **17**, 16 *pp.* (*No.* 11, 1951).

A critical review of the results obtained to date from twilight and night-sky observations of atm. Na I emission at 5 893 Å. In particular, the errors involved in the method of Vegard for the computation of screening height (H_s) and upper limit (H_u) of emission are discussed. From a recalculation of height values from the accumulated data of Vegard *et al.* the most probable values are $H_s = 42{\cdot}5$ km and $H_u = 104{\cdot}5$ km. D. R. BARBER

551.510.535

2280. Ionospheric behaviour in the F_2 region at Singapore. B. W. OSBORNE. *J. Atmos. Terr. Phys.*, **2**, 66–78 (*No.* 1, 1951).

Previous work on ionospheric behaviour at low latitudes has demonstrated the existence of ionospheric phenomena peculiar to equatorial regions, particularly during the mid-day period and after sunset, within the region of a "trough" of low F_2 layer critical frequency near the magnetic equator. Observations at Singapore (on the southern edge of this "trough") from November 1948 have shown the inter-dependence of F_2 layer critical frequency and height with the seasonal occurrence of thick layer effects. Ionospheric behaviour at Singapore during the December solstice shows marked differences from that at the equatorial station of Huancayo, Peru, during daylight hours. Layer height changes after sunset, and the associated occurrence of the equatorial scatter phenomenon, are discussed. Consideration is given to the interpretation of vertical incidence virtual height measurements under Singapore conditions of a thick F region. A.

551.510.535

2281. The ionization of the E layer, its evaluation and its relation to solar eruptions. K. BIBL. *Ann. Geophys.*, **7**, 208–14 (*No.* 4, 1951) *In French.*

According to a proposal for the discrimination between normal and abnormal layers, a definition for the critical frequency f_0E is given, which is also unequivocal for the cases of complex layers. Layers with a relatively small thickness are regarded as abnormal ones, even if this thickness is still measurable. The distribution of ionization is then more curved, than in the case of a "parabolic" normal layer. f_0E is the highest critical frequency of a normal layer, which precedes or coincides with the first discontinuity of height between the E- and F-echoes. This definition has been applied to the evaluation of ionospheric observations made at Freiburg 1950–51. The result is an essential diminution of the fluctuations in the daily variation and also of the monthly dispersion. During three investigated summer months all values more than 0·2 Mc/s above the median can be attributed to SID-effects. A.

551.510.535

2282. Studies on the sporadic E-layer. R. B. BANERJI. *Indian J. Phys.*, **25**, 359–74 (*Aug.*, 1951).

An attempt has been made to investigate the structure and properties of the sporadic E_s region of the ionosphere from a study of the fading of the echoes from this region. Statistical analysis shows that the echo consists of two components, one superposed on the other. One of the components is due to random scattering and the other to a steady reflection. This shows that the E_s region consists of a regularly reflecting region and a region of ion-clouds. A method for estimating the average number density of electrons in the clouds has been developed. It is found that the average number density is below that required for totally reflecting the exploring waves. Expressions for the variation of reflection coefficient with the variation of exploring frequency has been developed for a thin and for a semi-infinite layer (the electron distribution at the boundary is assumed to have a linear profile). The expression shows that it is possible from the observation of reflection-characteristics to distinguish between the two cases, and hence to investigate the structure of that part of the E_s region which gives rise to the steady echo. A.

551.510.535

2283. The *D*-layer of the ionosphere. A. P. MITRA. *J. Geophys. Res.*, **56**, 373–402 (*Sept.*, 1951).

After a résumé of the present state of knowledge, new theoretical studies are made on the formation and structure of the layer, based on contemporary knowledge. It is assumed that the *D*-layer is produced by ionization of O_2 at the first ionization potential. The number densities of electrons and ions are calculated for various heights, taking due account of the variations of atmospheric temperature and effective recombination coefficient with height. The number density distribution of electrons does not show any maximum; that of ions, however, gives a maximum at nearly the same height as that of the rate of ion production. The distributions obtained have been used to give (*i*) the variation of reflection height with solar zenith angle (for long and very long waves), and (ii) values of the coefficient of reflection for various frequencies at the low frequency range.

A.

551.510.535 : 523.72

2284. The modes of formation of the ionospheric layers. J. H. PIDDINGTON. *J. Geophys. Res.*, **56**, 409–30 (*Sept.*, 1951).

Ionospheric measurements made during eclipses are analysed and, together with recently acquired solar data, are used in a re-examination of the theories of the ionosphere. It is shown that: (i) The rates of disappearance of electrons in all the principal layers may be much higher than hitherto believed. If so, then the number of ionizing quanta needed is also greatly increased. (ii) There is probably a non-solar source of electron production in region *E* (and perhaps region *D*). It may be the electric currents flowing in the upper atmosphere which are also manifested by fluctuations in the earth's magnetic field. (iii) Solar ionizing radiation does not appear to originate (principally) either throughout the corona or near the photosphere, but in regions of rapid temperature transition in the chromosphere and lower corona. Excess emission occurs from regions of disturbance, often near sunspots. (iv) The emission spectrum of these regions may be strong in the quasi-Lyman spectrum of He II and in X-rays of wavelength ranging down to about 3 Å. During flares, X-rays of wavelength less than 1 Å may be emitted. (v) The *F*1 and *F*2 ionospheric layers may be accounted for if minor modifications of existing theories are made. The *E* and *D* layers may be formed by quanta of a few hundred and a few thousand electron volts, respectively, originating in the chromospheric transition region.

A.

551.510.535 : 537.56

2285. The negative ion concentration in the lower ionosphere. D. R. BATES AND H. S. W. MASSEY. *J. Atmos. Terr. Phys.*, **2**, 1–13 (*No.* 1, 1951).

The processes leading to the formation and destruction of negative ions in the upper atmosphere are considered in detail. Even if the former are improbably rapid, and the latter are improbably slow, the day-time equilibrium concentration of negative ions in the *D* and *E* regions does not seem to be sufficiently high to be readily reconcilable with the dynamo theory of the *L* and *S* magnetic variations. Thus on calculating the transverse conductivity of *E* by the usual method it is found to be such that the magnitude of the *L* current can apparently only be explained if the local tidal motion is 6 000 times greater than at ground level; and the most recent work on the interpretation of radio observations on the movements of the ionosphere is opposed to an amplification of this order. There seems also to be little doubt that the transverse conductivity of *D* is not as great as is demanded by the theory in its present form. The fade-out enhancement of the electron concentration in the lower ionosphere is briefly discussed. It is pointed out that the possibility that it arises from photo-detachment by Lyman (α) radiation from solar flares cannot be excluded.

A.

551.510.535 : 538.566.3

Radio wave propagation in the ionosphere. *See Abstr.* 1986–92

551.510.535 : 621.396.812.3

2286. Further results of fade-out statistics. D. STRANZ. *J. Atmos. Terr. Phys.*, **2**, 79–82 (*No.* 1, 1951) *In German.*

The investigation of the weak absorption of u.v. radiation by the corpuscular cone emitted by the sun has been continued by examination of 1949 records.

551.510.535 : 629.19

2287. Space travel and the ionosphere. W. DIEMINGER. "*Hochfrequenztechnik und Weltraumfahrt*," *Stuttgart, S. Hirzel Verlag* (1951) 7–18. *In German.*

A survey of physical conditions likely to be encountered by a rocket passing through the ionosphere. Gas pressure and the laws governing its decrease are expounded briefly; above 1 200–1 500 km the mean free path lengthens sufficiently to enable some molecules to escape from earth's gravitation. Gas composition: this seems to remain almost constant. Temperature: this is plotted against height, showing two minima and values up to 1 000°K in the extreme ionosphere. Ionization: characteristics are described briefly, also the occurrence of winds. The danger from meteors is also discussed.

551.510.41

2288. New lines of telluric methane. M. MIGEOTTE AND L. NEVEN. *Ann. Astrophys.*, **14**, 315 (*No.* 3, 1951) *In French.*

New observations of the solar spectrum from the Jungfraujoch station, combined with new measures of methane lines in the lab., yield 115 identifications of methane lines in the earth's atmosphere over the region 7·21–8·29 μ.

D. L. EDWARDS

551.513

2289. On horizontal motion in a rotating fluid. E. HØILAND. *Geofys. Publ.*, **17**, 26 *pp.* (*No.* 10, 1950).

Expressions are obtained for the induced circulation due to the earth's rotation and for the induced vorticity per unit time due to the induced circulation and from these the absolute vorticity of the particle considered is obtained. The fundamental effect of induced vorticity is considered in a general way for (*a*) motion in stationary cyclones and anticyclones; and (*b*) permanent cyclones and anticyclones, and some exact solutions are then obtained for the induced vorticity. A stream-line pattern is obtained for the zonal circulation at the earth's surface which

ives on each side of the equator 4 anticylonic cells entred at about 15°N (S) and 4 cyclonic cells centred t about 50°N (S). Instability due to absorption and mission of heat will cause a change of phase with atitude of the waves and alter the relative longitudinal position of cyclones and anticyclones. Finally he effect of the impulse theorem for horizontal notion of a limited part of the fluid is considered.

R. S. READ

551.513.1

2290. Some hydrodynamical properties of simple atmospheric oscillations with applications to the semidiurnal oscillation. P. THRANE. *Geofys. Publ.*, **18**, 36 *pp.* (*No.* 1, 1951).

The linearized hydrodynamical equations, including the energy equation, are applied to certain types of simple oscillations, resembling tidal waves but created by periodical supply and removal of heat. It is shown that the variation in the heat supplied can be computed if the pressure wave is known. If the phase angle of the pressure wave at sea level is independent of latitude and if changes of state, including adiabatic and isothermal changes are piezotropic, the phase angle must be independent of height. For the atmospheric semidiurnal pressure wave the phase angle is independent of latitude but variable with height. For a barotropic model atmosphere a sample form of oscillation with a 24 hr period considered by Margules and others satisfying the linearized equations does not agree with the exact hydrodynamical equations. An examination is made of the properties of oscillations with 12 hr or 24 hr periods, but limited to a region near the Pole. A fundamental difference in the hydrodynamical properties of the two oscillations is indicated quite apart from resonance. Non-linear perturbation equations with terms of 1st and 2nd order are applied to derive certain oscillation properties. Approximate values of the variation of the heat supplied and the vertical velocity in the semidiurnal oscillation are obtained, the pressure wave being known. The possibility of explaining this wave as a non-resonant oscillation resulting from thermal processes is discussed. The flux of heat through a model atmosphere having no other motion than that from the combined diurnal and semidiurnal oscillation is considered and a possible explanation of the preponderance of the semidiurnal oscillation is indicated. R. S. READ

551.513.2

2291. Diffusive separation in the upper atmosphere. L. M. JONES, L. T. LOH, H. W. NEILL, M. H. NICHOLS AND E. A. WENZEL. Letter in *Phys. Rev.*, **84**, 846–7 (*Nov.* 15, 1951).

Atmospheric samples were obtained with an improved technique using an Aerobee rocket at New Mexico, Dec. 19, 1950. When the samples were analysed by Paneth diffusive separation of the gases was shown, He and Ne increasing relatively to N, but A decreasing over the range tested, 64–72 km. In this range there should, however, occur a rapid temperature decrease and considerable turbulence and mixing rather than the quiescence for diffusive separation. Earlier tests on samples over the range 40–65 km had not shown this effect. Further tests over the range 70–100 km are planned. R. S. READ

551.521

2292. Calculating effective radiation with due regard to its diffuse nature. O. LÖNNQVIST. *Ark. Geophys.*, **1**, 441–51 (*Paper* 15, 1951).

Discarding the simplified assumption of purely vertical radiation and assuming that it may travel in all directions the previous formula for effective radiation [Abstr. 6901 (1950)] must be modified to read $F = \sigma T_0^4 . 10^{-2}[B + 0{\cdot}06t_0 + 0{\cdot}12(1 + \omega)y_m - 10 \ln \omega\rho_0]$, where the constant B is approximately 50. It is shown that no constant factor of general applicability, by which the coefficients of absorption must be multiplied when making the simplifying assumption of purely vertical radiation, can be given since it varies with the temperature lapse rate. It approximates to 1·65 with a variation mainly 1·55 to 1·75.

R. S. READ

551.521.3

2293. Practical formulae expressing the intensity and number of photons of ultra violet sunlight reaching the earth's upper atmosphere. J. GAUZIT. Note in *Ann. Geophys.*, **7**, 254–5 (*No.* 4, 1951) *In French.*

The author derives formulae for the intensity and number of photons of the light less than a given wavelength in terms of Planck's radiation formula. These are compared with values obtained from tables and are shown to be in good agreement. It is suggested that the formulae are easier to use than the standard tables. J. M. HOUGH

551.551

2294. Noise of the wind and the carry of sound in the free atmosphere. F. SPANDÖCK. *Z. angew. Phys.*, **3**, 228–31 (*No.* 6, 1951) *In German.*

It is considered that wind noise arises from turbulence and has a falling-off spectrum for both low and high frequencies. From measurements of screening of wind noise and of its influence on the amplitude, the distribution of sound in consequence of the sheltering effect has been calculated. On the basis of the fact that the frequency change of wind noise and the excitation of waves in the ear are similar, the possibility is discussed that the ear adapts itself to the conditions in the free atmosphere.

R. S. READ

551.574 : 536.7

2295. Thermodynamics of condensation in the atmosphere. L. DUFOUR. *Inst. Roy. Met. Belge Mem., No.* 42, 39 *pp.* (1951) *In French.*

The thermodynamic method employed is that developed by Defay in thermodynamic studies of surface tension. The two phases considered are a gaseous phase consisting of dry air and water vapour and a liquid phase consisting of water and dissolved salt separated by a superficial layer which is the seat of capillary and absorption phenomena. The development proceeds from a model which is globally equivalent to the complex real phenomenon, while the surface of separation remains homogeneous with mechanical, mass and energy properties equivalent to the real system. Physical-chemical variables and functions of state of the two phases are then applied for the mathematical development. R. S. READ

551.578.1

2296. Abnormal displacement of certain rain echoes. R. LHERMITTE. *C.R. Acad. Sci.* [*Paris*] **233**, 1210–12 (*Nov.* 12, 1951) *In French.*

Rain echoes appearing on the panoramic screen of a centimetric radar are registered periodically with the help of a cinematograph apparatus on standard 16 mm film at a rate of 5 images/min. At projection they are observed at 16 images/sec. Registrations have been made for 10 consecutive hours during a thunderstorm and show the precipitation moving with a speed and direction very near to the wind found in soundings. Sometimes with similar echoes the displacement is reversed. For three situations it was proved that although the cloud in the lower layers moved with the wind, the rainy zone can move extremely rapidly by tens of km. R. S. READ

551.578.4

2297. Experimental investigation of icing phenomena. D. MELCHER. *Z. angew. Math. Phys.*, **2**, 421–43 (*Nov.*, 1951) *In German.*

Artificial rime deposits of various types were produced in the wind tunnel and measurement carried out to establish the quantitative dependence of the deposit on temperature, H_2O-content, wind speed and material of the body to be iced. The growth of the rime on metallic surfaces was observed under the polarizing microscope. The second part describes an arrangement for studying rime in the open air, the purpose of which was to discover whether natural icing was a result of temperature effects (minute differences in temperature between air and solid body). In addition, the influence of the electric field (conductor submitted to direct and alternating tension) on the type of deposit was examined and measured. A.

551.578.7 : 551.594.21

2298. A new electrical effect during the formation of soft hail [graupel] in natural under-cooled mist. H. LUEDER. *Z. angew. Phys.*, **3**, 247–53 (*No.* 7, 1951) *In German.*

Existing theories of charge formation in thunderstorm clouds are critically examined. In order to test whether the formation of ice and hail particles is inherently connected with charge formation a novel device is described in which a small rod is rotated in a natural under-cooled atmosphere, any developing charges being measured by an e.s. induction method. Test results obtained on a mountain top are discussed and samples of continuous field records are reproduced. From the results obtained it is concluded that, in contradistinction to earlier laboratory measurements, a metallic body covering itself with a layer of ice when rotating in undercooled mist assumes a negative charge, thus suggesting a mechanism in agreement with Simpson's cloud model. It is suggested that the single undercooled mist particle, on meeting the rotating body, is partly deposited in the form of negatively charged ice while the remainder escapes in liquid form and positively charged.

R. H. GOLDE

551.578.7 : 551.594.21

2299. Electrification during the formation of soft hail [graupel] as a source of thunderstorm electricity. H. LUEDER. *Z. angew. Phys.*, **3**, 288–95 (*No.* 8, 1951) *In German.*

Having previously shown the polarity of electrification of ice particles in natural undercooled mist [preceding abstract], a physical-mathematical investigation is presented of the magnitude of this effect. The max. charge density on the growing ice surface is found to amount to $\sim 0{\cdot}2$ Coulomb/cm³. With increasing thickness of the ice layer charge formation ceases when the surface gradient reaches ~ 700 V/cm. The theoretically derived rate of charge increase is found to be confirmed by test results. The new process is thus shown to explain the charging of each ice particle in an undercooled cloud atmosphere even in the absence of a pre-existing e.s. field. After a lightning flash the e.s. field above the 0°c isotherm causes such an increase in the rate of charge formation as to explain the rapid recovery rate of the e.s. gradient after a lightning flash. R. H. GOLDE

551.593.5

2300. Blue sun and moon. W. PAUL AND R. V. JONES. Letter in *Nature* [*Lond.*] **168**, 554 (*Sept.* 29, 1951).

This phenomenon is attributed to preferential scattering of red light by atmospheric particles large enough not to satisfy Rayleigh's criterion of being much smaller than the wavelength of the incident light. N. CORCORAN

551.593.5

2301. Blue sun and moon. G. F. LOTHIAN. Letter in *Nature* [*Lond.*] **168**, 1086–7 (*Dec.* 22, 1951).

This phenomenon can be explained with fair approximation using the principles of physical optics. Results so calculated for water drops are quoted. G. F. LOTHIAN

551.593.9

2302. The annual variation of sodium D in the nightglow. F. E. ROACH AND H. B. PETTIT. *Ann. Astrophys.*, **14**, 392–8 (*No.* 4, 1951).

Photoelectric observations in the Mojave Desert of the Na *D* radiation in the nightglow for 37 nights over a 2½-year period are recorded. The intensity shows a maximum in the winter and a minimum in the summer in agreement with previous results by other investigators. The observations suggest that the region of maximum excitation moves from north to south as the general intensity level varies from maximum to minimum. A.

551.593.9

2303. Researches on the emission of the green line of the light of the night sky. D. BARBIER, J. DUFAY AND D. WILLIAMS. *Ann. Astrophys.*, **14**, 399–437 (*No.* 4, 1951) *In French.*

A detailed account and discussion of the results obtained from measures of night-sky emission, using a Roach photoelectric photometer with interferometric filters transmitting narrow bands of radiation at 5 577 Å and 5 180 Å. The 2 radiations have variable intensities correlating well from night to night, and month to month. Heights of emission are found to be 305 and 450 km respectively. There is evidence also of continuum radiation at 5 180 Å originating at *c.* 460 km. D. R. BARBER

551.593.9

2304. Sodium in the upper atmosphere. A. K. AHA. *Indian J. Phys.*, **25**, 375–86 (*Aug.*, 1951).

Surveys the available data for the Na phenomena in the upper atmosphere. It is shown that the most probable mode of production of the twilight flash is resonance excitation of neutral Na atoms in 35·65 km region by solar radiation λ5893, there being no significant effect of ozone screening. The possible excitation processes in the night air-glow are examined critically on the assumption that the height of the emitting layer is 250 km (as obtained by Barbier and Roach) and that above 100 km Na exists wholly in the ionized state (as shown by Bates). Two possible excitation processes are examined: (1) radiative recombination of Na^+ ions, and (2) mutual neutralization of Na^+ and O^- ions. The former requires impossibly high concentration of Na^+ ions, but the latter process cannot maintain the observed intensity of the radiation throughout the dark hours of the night. Hence it is concluded that extra-terrestrial particles must be bombarding the upper atmospheric regions, ionizing and/or exciting the neutralized Na^+ ions. Alternatively, it may be assumed that Na atoms are entering the atmosphere from interplanetary space. A.

551.593.9

2305. On the diurnal variation of [O I] 5577 in the nightglow. F. E. ROACH AND H. B. PETTIT. *J. Geophys. Res.*, **56**, 325–53 (*Sept.*, 1951).

Observations in the Mojave Desert of the diurnal variations of the zenith intensity of the forbidden oxygen line at 5 577 Å for ten nights over a two-year interval are recorded. In general, a maximum of intensity occurs at local midnight, ±2·5 hours. A detailed study of one night is reported wherein the diurnal variation of regions of the sky other than the zenith are shown to follow time patterns similar in general but with significant variations in detail. The intensity changes of various parts of the sky are interpreted as geographical variations of local zenith intensity. Isophotal plots of these geographical variations throughout the night indicate the presence of definite patterns in the upper atmosphere. During the post-twilight period, an enhancement of intensity is observed in the western sky. In the pre-dawn observations, no enhancement is noted in the eastern sky. Between the post-twilight and pre-dawn, the intensity goes through a maximum which is partially localized to the north of the station. Evidence is presented which indicates that the over-all intensity change can be described as a fixed excitation pattern on the dark side of the earth through which a given observer seems to move with the rotation of the earth. The character of the pattern seems to change with the season. The variation of intensity with zenith distance for the whole night indicates an effective height of emission of 250 km. A.

551.593.9 : 551.594.5 : 551.510.535

2306. Continued investigations on the spectra of aurora and twilight and the ionospheric temperature. L. VEGARD, E. TØNSBERG AND G. KVIFTE. *Geofys. Publ.*, **18**, 16 *pp.* (*No.* 4, 1951).

A review of progress along 3 main lines of work: (i) relative intensities of selected auroral lines and bands (Int. 5 577 Å = 1) at lower and upper borders of rays and arcs; (ii) ionospheric temperature evaluation for 110–130 km level, based on intensity distribution in rotational bands (3 914, 4 287 Å) of N; and (iii) measurement of screening height, and upper limit of atmospheric Na emission from times of disappearance of *D* lines at zenith, and at 10° above W horizon respectively. Both red O I doublet and negative N bands show enhanced intensity with increasing altitude above base of auroral rays and streamers. Ionospheric temperature values derived from rotational band intensities vary from *c.* 240°K at lower border to *c.* 220°K at upper limit of auroral rays. Mean values obtained during 1942 and 1946 for screening height (O_3 layer) and upper limit of emission (Na layer) were 35 km and 99 km respectively with an average depth of 27 km for the Na layer.

D. R. BARBER

551.594.221 : 537.523.4 : 535.338–15

The near infrared spectrum of lightning. *See Abstr.* 1628

551.594.221 : 621.316.98

2307. Lightning phenomena. E. L. HARDER AND J. M. CLAYTON. *Westingho. Engr*, **11**, 106–11 (*July*, 1951).

The use of c.r.o., discharge counter, magnetic links, fulchronograph and magnetic surge-front recorder for lightning investigations is briefly described and field results are summarized in tables. The protection of h.v. transmission and distribution lines and of substations is briefly considered. Some results are given of field investigations, reference being made to a lightning flash which is claimed to have discharged a current of 345 kA into a tall lightning observation post. R. H. GOLDE (R)

551.594.5 : 535.338.4

2308. An auroral spectrogram and the results derived from it. L. VEGARD AND G. KVIFTE. *Geofys. Publ.*, **18**, 23 *pp.* (*No.* 3, 1951).

A spectrogram taken on night of Feb. 23–24, 1950, with *f* 1·2 Cojan 2-prism glass spectrograph has been analysed. In region 3 880 Å–6 300 Å, 375 lines and bands are identified and listed with measured wavelengths, of which 310 have not previously been detected. The majority of these emissions originate from O and N atoms in neutral and ionized states. Balmer emissions at H_β and H_γ appear as diffuse bands through Doppler displacement. Temperature evaluation from intensities of rotational components of *R*-branch of N band at 3 914 Å gives $T = 219$°K.

D. R. BARBER

551.594.6

2309. A note on the similarity of certain atmospherics waveforms. W. F. ZETROUER AND W. J. KESSLER. *J. Franklin Inst.*, **252**, 137–41 (*Aug.*, 1951).

This note reports a remarkable uniformity observed among waveforms of atmospherics associated with a common centre of thunderstorm activity. Photographic results of observations during the day and night are reported. From 104 night-time waveforms identifiable with a surface cold front extending over the mid-western states, 55% are found to exhibit similar fine-structure characteristics. Of the 520 day-

time waveforms associated with a surface cold front moving over the edge of the Gulf Stream, 41% are classified as similar. The waveforms of the latter observation are further classified into two subgroups depending upon the polarity of the initial maxima of the observed waveforms. A.

BIOLOGY 57/59

578.088.5

2310. Physical aspects of the biological action of ionizing radiations. J. Read. *Brit. J. Appl. Phys.*, **2**, 337–45 (*Dec.*, 1951).

The influence of such physical factors as the linear ion density created by different radiations, the presence of dissolved oxygen or certain other molecules, and the dose rate, on the production of biological effects by ionizing radiations, is discussed. Certain radiochemical experiments are outlined which show similarities to radiobiological experiments. Hypotheses are suggested which attempt to correlate and explain some of the biological observations. A.

578.088.781

2311. A new micro-electrode for electro-physiological work. R. A. Weale. Letter in *Nature* [*Lond.*] **167**, 529 (*March* 31, 1951).

Glass-capillaries of int. dia. $< 10\,\mu$ are placed with their narrow end in a saturated solution of $AgNO_3$. The cathode is formed by a piece of silver wire pushed into the non-capillary portion of the tube. Silver is deposited through the capillary orifice, the plating current being controlled by a relay which cuts it off when the capillary is filled. The resistance of the electrode $\ll 1\,500\,\omega$. Two figs. are given.

R. A. WEALE

578.088.781

2312. Micro-electrode for electro-physiological work. J. Worst. Letter in *Nature* [*Lond.*] **168**, 749 (*Oct.* 27, 1951).

The method for making micro-electrodes [preceding abstract] is improved by observing the electrolytic process under a high-power microscope. The "feathery" effect is due to too high a rate of crystal growth. The resulting electrodes ($5\,\mu$ dia.) have an average resistance of 1 ohm. R. A. WEALE

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.014.462.481

2313. Method for the photographic detection of penetrating corpuscular radiation in human tissue. J. Eugster and L. Jenny. *Experientia*, **7**, 468–9 (*No.* 12, 1951) *In German.*

It is proposed to register the penetration of cosmic rays into biological material by the photographic emulsion technique. From a study of the tracks, an examination of the biological effects of cosmic rays would be possible. To introduce the particle-sensitive material into the cellular tissue, a small amount of liquid silver-halide emulsion is injected. After processing, this should then serve as indicator for penetrated particles. Preliminary tests were carried out on dead human skin. Further experiments are to be carried out on living material. A.

612.843.31

2314. Recent concepts of retinal color mechanism. I. Contributions from psychophysics. S. A. Talbot. *J. Opt. Soc. Amer.*, **41**, 895–918 (*Dec.*, 1951).

Since König, experiment has yielded 6 different sets of 3 "primary processes" for tricolour vision in the fovea. Their variation with test method, and conflict with other data, suggest only an indirect relation to the absorption curves of receptors. Blue and yellow in the retinal periphery, in the central fovea, and in transient effects, act as if coupled physiologically. Yellow proves independent of red and green, and blue has many characteristics of rod function. To adjust the Helmholtz view of deficiency to modern observations, new mechanisms for white and hues are needed in the cortex. The Müller theory adds black and locates in the retina this inner zone; but likewise fails to assign it a physiological mechanism. Recent experiments confirm the retinal location of both yellow and black mechanisms; hence an opponents theory seems unavoidable. The psychophysical evidence calls for unsymmetric synaptic connections before the "primary processes," and also after them to create hues and luminosity separately. A.

612.843.31

2315. Recent concepts of retinal color mechanism. II. Contributions from anatomy and physiology. S. A. Talbot. *J. Opt. Soc. Amer.*, **41**, 918–41 (*Dec.*, 1951).

Analysis of spectral response peaks shows that receptor curves can hardly be deduced by psychophysics or nerve physiology. Conversely, however, even the two known dyes may suffice for all the spectral response peaks, narrow or wide. The detailed structure of the receptor is basis for a masking mechanism which accounts for 3 absorptions, peaked near 510, 540 and 620 mμ. From these, synaptic mechanisms can produce 3 colour primaries at the bipolar level, and 6 selectivities at the fibre level. The synaptic detail for this (based on Polyak, Willmer, Müller and Adams) separates white and provides for dichromasies, unitary hues, saturation and non-linearity of colour-limens. By such mechanism, colour antagonists may be transmitted by simple modulation of a mean frequency. Transmission has only a transient appearance, due to a series of electrochemical counter-effects which give minimal signal for steady-state information. Amacrine cells and retinal polarizations apparently relate to this, and thereby constancy and lateral induction of black and hue. Acuity in continuous illumination, in a system which transmits mainly transients, is handled by a scanning system. Other counterparts to colour television are discussed. A.

612.843.37

2316. The photochemical basis of rod vision. G. WALD. *J. Opt. Soc. Amer.*, **41**, 949–56 (*Dec.*, 1951).

The photochemical system upon which the excitation of rod vision depends has been analysed, and all its component processes brought into free solution. The only action of light in this system is to convert rhodopsin to the highly unstable lumi-rhodopsin. This bleaches in the dark via the intermediate metarhodopsin to a mixture of the carotenoid, retinene$_1$ and the colourless protein, opsin. Retinene$_2$ is reduced to vitamin A_1 by the coenzyme, reduced cozymase, acting in concert with the enzyme retinene reductase or alcohol dehydrogenase. These are the degradative processes in the rhodopsin system. The resynthesis of rhodopsin from these products is the basis of dark adaptation. A mixture of opsin and retinene$_1$ forms rhodopsin spontaneously in the dark. The retinene reductase system, left to itself, reduces retinene$_1$ to vitamin A_1. In the presence of opsin, however, it oxidizes vitamin A_1 to retinene$_1$ as rapidly as retinene$_1$ condenses with opsin to form rhodopsin. A mixture of four substances in solution performs all the reactions of the rhodopsin system: vitamin A_1, cozymase, alcohol dehydrogenase and opsin. Opsin is the only one of these specific to the retina. The synthesis of rhodopsin requires the presence of free sulfhydryl (— SH) groups in opsin. Conversely when rhodopsin bleaches, two such groups are liberated for each retinene$_1$ formed. Based upon these changes, an artificial system has been devised in which the bleaching of rhodopsin results in an electrical variation. This may provide a model for the excitation process in rod vision. A.

612.843.37

2317. The variation of critical fusion frequency with brightness at various retinal locations. R. T. BROOKE. *J. Opt. Soc. Amer.*, **41**, 1010–16 (*Dec.*, 1951).

Critical frequency curves for brightness between — 3 and + 3 log millilamberts were determined for a 2° test field of green light at the fovea and at 10°, 20°, 30° and 40° in the periphery. The procedure used allowed an image of a 2 mm circular aperture to be focused in the plane of the pupil. Tests showed that astigmatism did not influence the data obtained for the peripheral stimuli. The curve of log critical frequency against log brightness for foveal observation does not show an inflection in its rise to a maximum. The curves for peripheral observations rise to a plateau at low brightnesses, dip at medium to low brightnesses, and rise again to a maximum, thus giving the conventional "cone" curve at high brightnesses. The maximum is lower and lower for locations increasingly distant from the fovea. Data on colour thresholds indicate that rods probably make their contributions to the initial part of the "cone" branch. Comparison of data for green and white central fields shows that these colours give data that superimpose for equivalent foveal stimulation. For peripheral stimulation a slight shift of the curve for green (with respect to the curve for white) seems to occur in the direction of lower brightnesses. The latter effect is interpreted to be a Purkinje shift. The Purkinje shift is greatly emphasized when orange and green peripheral fields are used. Green light, matched foveally with orange light, is more effective than orange in providing peripheral flicker. The data are interpreted to mean that rods function and interact with cones at levels of brightness that are often considered to be photopic. A.

612.843.44

2318. The distribution of light in the retinal image of a point source. A. ARNULF, O. DUPUY AND F. FLAMANT. *C.R. Acad. Sci.* [*Paris*] **233**, 974–6 (*Oct.* 22, 1951) *In French.*

The brightness of an image at the centre of its diffraction pattern is given by $\pi\phi\omega^2/4f^2$, where ϕ is the luminous flux, ω the pupillary diameter, and f the posterior focal distance of the eye. A graphical relation is obtained between ϕS, where S is the threshold intensity, and d, the distance from the [foveal] centre. A family of curves relating $S = F(d)$ is deduced, the values being extrapolated to $\omega = 4$ mm. The theory is tested with the Foucault test: calculation and experiment agree. The authors conclude that foveal visual acuity with natural pupils is largely controlled by light scattered in the retinal tissues.

R. A. WEALE

612.843.611

2319. Influence of the state of accommodation on the visual performance of the human eye. J. M. OTERO. *J. Opt. Soc. Amer.*, **41**, 942–8 (*Dec.*, 1951).

The contribution of the accommodation to some visual tasks, particularly in the range of low luminous levels, is considered. Theories are described regarding accommodation as well as the changes produced in the eye during the accommodation process. The visual process, when the eye is adapted to darkness and the luminous stimulus has luminances not bigger than a given value, is described as well as the phenomena of night myopia and presbyopia, which appear when the eye is working under such conditions, and the influence which both phenomena have on the visual performance. These latter effects are related to the mechanism of accommodation, since it involves a loss of the accommodative faculty. A critical study is given of the causes proposed by different researchers in order to explain the phenomenon of night myopia, and finally experimental evidence is presented proving that the main cause of night myopia is closely related to the mechanism of accommodation. Measurement of the size of the Purkinje images by photographing the eye in full darkness provides a measure of night myopia. It was observed that the position of rest of the eye-lens, i.e. the position it takes when there is no stimulus to put the mechanism of accommodation in action, is not focused to infinity but to a distance of about 0·8 m. The discovery of this rest position of the eye gives a more logical construction to the Helmholtz–Gullstrand theory of accommodation. A.

612.843.63

2320. Visual power and visibility. G. J. FORTUIN. *Philips Res. Rep.*, **6**, 347–71 (*Oct.*, 1951).

This is the continuation referred to in the last sentence of Abstr. 9871 (1951).

612.843.63

2321. Vision and resolution in the central retina. B. O'BRIEN. *J. Opt. Soc. Amer.*, **41**, 882–94 (*Dec.*, 1951).

The relation of the structure of the retina to factors

influencing visual acuity is examined in some detail. Dimensions of the foveal cones have been redetermined in a series of measurements on histological materials from several sources. In no case has centre-to-centre distance between the most central cones in adult human eyes been found less than $2{\cdot}0\mu$ nor greater than $2{\cdot}3\mu$, these being values for the living eye, due allowance being made for shrinkage of the preparations. Photomicrographs of the central foveal mosaic are shown to illustrate the rapid increase in centre-to-centre distance between cones a short distance from the small central fovea. These results are in general agreement with those of Polyak. This cone mosaic is in good accord with the observed effect on resolution acuity of the particular location of the image within the fovea. The central cones are of such size that the optical system of the eye at optimum pupil concentrates approximately three-quarters of the energy of a star image into a circle containing three cones, but some additional optical mechanism must exist in the retina to prevent loss of this image quality by spread of rays after the focus, but within the retinal depth represented by the length of the cones. Optical processes occurring within the cones are considered in detail. It is shown that not only is the Stiles and Crawford effect explained quantitatively by these processes, but also that the spread of rays beyond the focus is prevented, so that the retinal mosaic can behave as though the light receptors were concentrated in the focal plane. This same process also makes possible greatly increased light absorption per unit weight of cone pigment. The structure of the retina is thus consistent, numerically, with resolution acuity at high illumination but does not account for observed changes in acuity as retinal illumination is reduced. Ballistic stimulation of 10 microsecond duration eliminates effect of eye movements and serves to test both the Hecht theory of change of acuity with luminance, and the alternate hypothesis that very few quanta are absorbed per cone at threshold, statistical variation in this number accounting for the acuity change. The result of these experiments indicates that neither theory can be accepted. A.

612.843.721

2322. Effect of colour on sensitivity in stereoscopy. H. ZETSCHE. *Z. angew. Phys.*, **3**, 303–8 (*No.* 8, 1951) *In German.*

The use of colour photography in photogrammetry has not been extensively studied. By means of laboratory apparatus the author has measured the sensitivity of the eye to stereoscopic relief for a wide range of conditions, particularly the colour contrasts by means of which the stereoscopic effect is obtained in the absence of brightness contrast. He finds that the sensitivity is closely proportional to the colour difference expressed on the scale of equal hue differences established by McAdam. The characteristics to be looked for in an observer are discussed.

J. W. T. WALSH

612.85

2323. On the unsolved problems in the theory of the sensation of pitch. L. CREMER. *Acustica*, **1**, 83–96 (*No.* 2, 1951) *In German.*

The classical theory of the sensation of pitch is briefly given. The observations of v. Békésy of wave movements along the basilar membrane are discussed from the point of view of their derivation from the anatomy of the inner ear. The localization of displacement is not very selective. The selectivity improves for the first derivative of the basilar membrane wave and still more for its second derivative. As the ear can detect, on the one hand, temporal changes of only $\frac{1}{30}$ sec and on the other frequency differences of 3 c/s, it must on the uncertainty principle contain either an adaptable analyser or two frequency meters; the rhythmic property of nerve impulses provides for the possibility of such a double frequency measurement. If the time period is shorter than the refractory period, a single nerve fibre can only be excited every other period. This gives a physiological basis for the appreciation of consonant intervals even when the two tones are sounded one after the other. At low frequencies and sufficient intensities additional impulses may be excited and may be responsible for the well known steeper increment of loudness at low frequencies. Many psychological experiments show that the fundamental may be heard by the rhythmic action of the nerve impulse. The twofold estimation of pitch can give a physiological basis for our double system of musical symbols, e.g. c and c_1. A.

612.85

2324. On the failure of the Weber experiment in an anechoic room. H. MOL. *PTT-Bedrijf*, **4**, 13–14 (*Oct.*, 1951) *In Dutch.*

612.85

2325. On the dynamics of the cochlea. H. FLETCHER. *J. Acoust. Soc. Amer.*, **23**, 637–45 (*Nov.*, 1951).

It is assumed that a length of the basilar membrane which is equal to its width at each position vibrates as a unit, and that the forces exerted upon it by adjacent units are negligible compared to that exerted by the difference in pressure in the scala vestibuli and scala tympani. The boundary conditions at the stapes end is simply that the pressure difference in the two canals is equal to P_0 any desired pressure difference. However, at the helicotrema the pressure difference must be equal to that between the two ends of the capillary opening at the helicotrema. Then from the fundamental hydrodynamical equations and the experimental constants obtained by Békésy it is shown that the speed of sound through the liquid of the inner ear may be considered infinite compared to the speed of the wave along the basilar membrane. In other words, the liquid may be considered incompressible so that the rate of liquid displacement at the oval window is equal to that at the round window, and is also equal to that produced by flexure of the basilar for frequencies above 200 c/s. Below this frequency some of the liquid goes back and forth through the helicotrema. With these assumptions, the following quantities were calculated from the fundamental dynamical equations and found to be in good agreement with the experimental results of Békésy; (*a*) displacement amplitudes and phases of the basilar membrane at different distances from the stapes and for different frequencies, (*b*) time for wave to travel from stapes to various distances from stapes, and (*c*) volume displacement, at various frequencies, per dyne difference of pressure at oval window and that at round window. A.

612.85

2326. On the threshold and loudness of repeated bursts of noise. I. POLLACK. *J. Acoust. Soc. Amer.*, **23**, 646–50 (*Nov.*, 1951).

The loudness and threshold of an interrupted white noise (of constant sound-time fraction) was studied over a wide range of interruption frequencies. White noise has the useful property that, when interrupted, no spectral changes result in the white noise spectrum (in the frequency range passed by a dynamic earphone). Both at the threshold and at equal-loudness, less energy is needed for an interrupted noise than for a continuous noise. In many cases, an interrupted noise (sound-time fraction of 0·45) sounds louder than a continuous noise of the same burst amplitude (but of greater energy). There is a broad minimum, in the intensity required at equal loudness, for interruption rates between 2–10 per sec. A conceptual formulation to encompass the results is presented. A.

612.85

2327. Sensitivity to differences in intensity between repeated bursts of noise. I. POLLACK. *J. Acoust. Soc. Amer.*, **23**, 650–3 (*Nov.*, 1951).

Thresholds for the detection of a decrement in noise intensity between repeated bursts of noise were determined as a function of the duration of the interval between successive bursts. The results indicate a *critical duration* (55 milliseconds) between successive noise bursts: (1) above which, the differential threshold is constant and independent of the interval between successive bursts, and (2) below which, the differential threshold increases proportionately as the interval between successive bursts decreases. Since an equivalent critical interval has previously been obtained by several different independent measures of auditory persistence, the observed deterioration of differential sensitivity is interpreted in terms of the overlap or addition of auditory persistence with the direct effects of stimulation. A.

612.85

2328. On the measurement of the loudness of white noise. I. POLLACK. *J. Acoust. Soc. Amer.*, **23**, 654–7 (*Nov.*, 1951).

Scales of loudness for complex sounds have usually been obtained by determining the equal-loudness relation between the complex sound under investigation and a sound for which a scale of loudness is already available, e.g. a pure tone of 1 000 c/s. It is possible, however, to determine scales of loudness for complex sounds without appeal to pure tones or without extrapolation from pure-tone data. This was done in the present experiment. Loudness measurements were carried out by several independent procedures for a 1 000-cycle tone and for white noise. The agreement among the different procedures indicates satisfactory internal consistency among the several methods of determining loudness scales. A suggested scale of loudness for white noise, based upon all available data, is presented. A.

621.85

2329. Pitch and intensity. C. T. MORGAN, W. R. GARNER AND R. GALAMBOS. *J. Acoust. Soc. Amer.*, **23**, 658–63 (*Nov.*, 1951).

Presents data for changes of pitch with intensity for 18 ears, for frequencies from 125 c/s to 8 000 c/s, and for intensities up to a loudness level of approximately 100 db. There are wide individual differences, but most observers show very small changes (less than 2%) of pitch with intensity. In general, as intensity is increased, pitch falls at low frequencies and rises at high frequencies. Two different methods of measuring pitch-intensity changes showed no significant difference. A.

612.85

2330. Some effects of interaural phase differences on the perception of pure tones. W. R. GARNER AND M. WERTHEIMER. *J. Acoust. Soc. Amer.*, **23**, 664–7 (*Nov.*, 1951).

Fifty-four naive observers were asked to report whether they could hear a difference between two successive tones which differed only in respect to which ear was leading in phase angle. They were not given specific suggestions to listen for a particular effect, but were later asked what they had heard. Two intensities, eight frequencies and seven phase leads were used. The major conclusions from the results are: (1) All observers heard differences due to phase and identified the differences as localization, although for most the localization was in terms of which ear was stimulated rather than in terms of apparent localization of a sound source. (2) Pitch and loudness differences also occurred, but cannot be explained on the assumption that only one ear was effectively stimulated. (3) Measures of phase-difference thresholds, upper frequency limits and time-difference thresholds show approximately the same results as are obtained with other methods. A.

612.85

2331. Physiological demonstration of a property of the inner ear predicted by Békésy's model. K. LOWY. Letter in *J. Acoust. Soc. Amer.*, **23**, 716–17 (*Nov.*, 1951).

Using the micro-electrode technique of Galambos and Davis, the action potentials were recorded from auditory elements stimulated by a narrow frequency band. The results support Békésy's theory that maximal stimulation takes place in specific locations along the basilar membrane. A. B. WOOD

612.85

2332. A theory of the action of the cochlear resonators. R. GUELKE. *J. Acoust. Soc. Amer.*, **23**, 717–19 (*Nov.*, 1951).

The hypothesis is put forward that the mechanism of hearing may involve a building up of vibrations, and the damping of these vibrations when they reach a definite amplitude. This is able to explain the conversion of sound intensity reaching the ear into impulse frequency as measured on the nerve fibres. The hypothesis also reconciles the speed of response of the ear with the high pitch sensitivity and consequent sharpness of resonance of the aural resonators. A model is described which converts amplitudes into pulse frequencies by using a damping mechanism when a definite amplitude is reached. A.

612.85

2333. Tone sensation produced by repetitive trains of auditory "click" stimuli. W. T. CATTON. Letter in *Nature* [*Lond.*] **168**, 882 (*Nov.* 17, 1951).

The author has observed that a sensation of tone

arises by presentation of trains of very short pulses, each pulse of duration of 0·20 msec, and each train consisting of two pulses only. At a separation of 1 msec the sensation was that of 1 000 c/s tone; at 2 msec the tone was 500 c/s; 4 msec, 250 c/s, and so on. The observations lend further support to the view of Pumphrey and Gold that the resonator elements of the cochlea possess a high Q factor.

A. B. WOOD

612.858.72

2334. Neuro-psychological relations between phonation and audition. R. HUSSON. *Ann. Telecommun.*, **6**, 273–7 (*Oct.*, 1951) *In French.*

Knowledge recently acquired of the purely cerebral response to the vibration of the vocal cords and its integration in singing by the rhythmic nervous activity of the auditory centres, has placed questions of voca-auditive effects in the field of neurology and of cerebral physiology. Experimental researches have established three distinct brain centres: bulbous, diencephalic and cortical. A. B. WOOD

614.898

2335. Some problems of radiation protection. W. V. MAYNEORD. *Brit. J. Radiol.*, **24**, 525–37 (*Oct.*, 1951).

A description of a full-scale protection service on radiation workers in a hospital. The relative merits of condenser ionization chambers and of photographic film for radiation measurements are discussed together with the significance of serial blood counts. The level of dose received by the various groups of workers, isotope group, diagnostic department, radium nurses, general physicists, synchroton group and radiotherapy radiographers is given in diagrammatic form. The average is 60–70 mr per week. As regards correlation between mean dosage rate and total white blood cell count, it appears that at a level of about 100 mr per week there is probably a small decrease in the mean count of the group. After one year of operation of the service the doses received have been reduced to less than one-half, even though they were previously quite carefully controlled.

T. A. CHALMERS

614.898

2336. The use of lead shot for protection from gamma radiation. A. NIGHTINGALE. *Brit. J. Radiol.*, **24**, 568–71 (*Oct.*, 1951).

Some experiments on the use of lead shot of about 0·1 in dia. in cavity walls. It is concluded that it may safely be used instead of solid Pb, at least in thicknesses above 1·4 in for personnel protection against γ-rays. The equivalent thickness of Pb is about 70%. Pb shot is unsuitable for shielding fixed objects such as photographic material. The dia. of the Pb shot should be not greater than the effective dia. of the source. T. A. CHALMERS

615.849

2337. New techniques for superficial therapy with beryllium-window X-ray tubes. T. H. ROGERS. *Cath. Press*, **8**, 8–12 (*No.* 4, 1951).

Characteristics of the OEG-60 tube (50 kV, 50 mA), are given and depth dose curves with 1 and 2 mm Al filter over the beryllium window are compared with those for a 100 kV tube. F. T. FARMER

PHOTOGRAPHY 77

771.534.53 : 537.531 : 548.733

2338. The use of film in X-ray diffraction studies. M. H. VANHORN. *Rev. Sci. Instrum.*, **22**, 809–11 (*Nov.*, 1951).

Because of the weakness of diffracted beams, it is necessary to work in the low-gradient "toe" portion of the characteristic (D-log$E$) curve. The curve shape in this region is the same for all types of X-ray film commonly used, even when development is greatly prolonged. The shape of the entire characteristic curve is insensitive to radiation quality, but the relative speeds of different films change considerably in the range of wavelengths of interest to diffractionists. For photographic photometry, the linear density-exposure range can be extended by proper selection of the processing conditions. A.

778.33 : 537.531

2339. The photographic action of X-rays. J. R. GREENING. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 977–91 (*Nov.*, 1951).

The variation of photographic blackening with intensity, exposure, the thickness of material round the film, the angle of incidence and the wavelength of X-rays, are examined theoretically and, with one exception, experimentally. A detailed theoretical investigation is made of the energy absorption in the AgBr grains, consideration being given to the energy lost by scatter and fluorescence and to the electron interchange between the AgBr grains and the surrounding gelatine and other material. It is concluded that for the majority of emulsions there will be no variation of blackening with X-ray intensity and that the photographic density will be proportional to the exposure at low densities. At very short wavelengths the blackening is critically dependent upon the thickness of material round the emulsion. Photographic density decreases with increase of angle of incidence of X-rays, the maximum decrease observed being about 17%. Within the wavelength range examined experimentally (0·020 to 0·353 A.) the photographic density was approximately proportional to the energy absorbed by the AgBr. The density per röntgen varied by a factor of 42 in this range. The variation of density per röntgen with wavelength and angle of incidence limits the applications of photographic methods of X-ray measurement. Methods by which emulsion manufacturers can reduce these variations are suggested. A.

778.33 : 539.167.3

Deuteron activation of and autoradiography as coupled techniques in tracer experiments. *See Abstr.* 2083